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Conference Report

YUCOMAT 2023: An International Advisory Board Member's Digest †

Vuk Uskoković [1,2]

[1] Advanced Materials and Nanobiotechnology Laboratory, TardigradeNano LLC, Irvine, CA 92604, USA; vuk.uskokovic@tardigradenano.com or vuskokovic@sdsu.edu

[2] Department of Mechanical Engineering, San Diego State University, San Diego, CA 92182, USA

† YUCOMAT 2023: The 24th Yugoslav Conference on Materials, Herceg-Novi, Montenegro, 4–8 September 2023.

Abstract: The 24th edition of the Yugoslav Conference on Materials (YUCOMAT) organized annually by the Materials Research Society of Serbia (MRS-Serbia) was held in Herceg Novi, Montenegro, from 4 September to 8 September 2023. The conference attracted 212 participants and nearly 200 presenters, 17 of which were plenary speakers, while the rest were assigned regular oral or poster presentations. The participants came from over 20 different countries of the world, the most represented among which were Serbia, Ukraine, Poland, Czech Republic, United States, Montenegro, Lithuania, Italy, Republic of Korea, Romania, Germany, and China. Outside of the five plenary sessions at YUCOMAT and a special session dedicated to MXenes, the conference was divided to five symposia: (i) advanced methods in synthesis and processing of materials; (ii) advanced materials for high-technology applications; (iii) nanostructured materials; (iv) eco-materials and eco-technologies; and (v) biomaterials. In this report, a member of the International Advisory Board of MRS-Serbia gives a digest of the conference, alongside providing a few historical remarks.

Keywords: international conference; materials science and engineering; nanostructured materials; physics and chemistry of solid state; synthesis and characterization

1. Introduction

For a scientific conference in a small country to provide as thorough and focused a perspective on the forefront of materials science of the day as YUCOMAT has achieved year after year will remain a challenge for a likely very long time. Materials science is as broad as a discipline in natural sciences can get, yet rarely are any of the hottest topics in it not mentioned at YUCOMAT conferences. This is despite only around 200 presentations, both oral and poster, that are shared each year at YUCOMAT. This breadth, paired with the rich tradition and spoiling of the audience with an extraordinary lineup of speakers, has made YUCOMAT stand out in the multiverse of similar conferences held all over the globe.

The first YUCOMAT was held in 1995 and this year's YUCOMAT was the 24th edition of the conference, which was organized biannually until 2003 and annually after 2003. Relative to the global standards, YUCOMAT has been a small conference, never exceeding approximately 200 participants since its founding. Despite that, disproportionally to the number of participants, YUCOMAT may classify as one of the most elite meetings in materials science in the world. Only at this year's meeting, for example, according to the MRS-Serbia founder and president, Dragan P. Uskoković [1], have 7 out of the 30 most-cited materials scientists lectured, while most other plenary lecturers have established stellar standards of academic publication and impact in their respective sub-disciplines. In short, YUCOMAT conferences never overwhelm the participants with the amount of material presented, but allow for a thorough, in-depth view of the trendiest topics of research in materials science and engineering on the world stage. They also allow for the participants' networking in the most scenic and intimate setting for a scientific conference imaginable.

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YUCOMAT has been an international meeting since its founding. From the first conference in the new century, it became mandated that all presentations be in English, the language that distilled itself in the second half of the 20th century as the official language of science, following the periods of dominance of German and, even earlier, French [2]. This year's conference took place between September 3 and September 8 in Herceg Novi, Montenegro, its home since founding. The attendees (Figure 1) came from 28 different countries of the world, the most represented among which were eastern European countries, namely Serbia, Ukraine, Poland, Czech Republic, Lithuania, Romania, and Montenegro. Research centers and academic institutions from countries such as the United States, Germany, Republic of Korea, France, and China sent relatively numerous delegations, too. Outside of the five plenary sessions and the special symposium on the biological assessment of MXenes, the conference contained five symposia: (i) advanced methods in synthesis and processing of materials; (ii) advanced materials for high-technology applications; (iii) nanostructured materials; (iv) eco-materials and eco-technologies; and (v) biomaterials.

Figure 1. A group photo with many of the attendees taken on the first day of the conference.

2. Opening Ceremony

As at all other YUCOMAT conferences in the past, this year's opened with the speech from the MRS-Serbia founder and president, Dragan P. Uskoković (Figure 2). The basic numbers were reported, including the fact that between 190 and 200 works were about to be presented during the five days of the conference. Over 100 of them were posters, while around 50 were regular talks and almost 20 were plenary lectures. Presentations were distributed between the two lecture halls, which are no more than thirty feet apart, and a special presentation was organized on Wednesday afternoon, dedicated to the international project proceeding with the participation of two Ukrainian institutions and nine institutions from the European Union: "Towards MXenes Biomedical Application by High Dimensional Immune MAP-ing". Following last year's charitable campaign, the European Office of Aerospace Research and Drexel University have enabled the free stay in the resort for 43 participants from Ukraine, while MRS-Serbia waived their conference fees.

Figure 2. President of the MRS-Serbia, Dragan P. Usković, giving the welcome address.

Dragan Usković also gave some historical remarks about the conference site, focusing especially on the coastal town of Herceg Novi, where all YUCOMAT conferences to date have been organized. He highlighted how this town had attracted and inspired many artists, writers, and scientists in the past. In 1966, in Herceg Novi, the first Yugoslav-Soviet School of Powder Metallurgy and Ceramics was organized, which subsequently became the nucleus for the formation of the International Institute for the Science of Sintering. The first conference of this institute was held in 1969 in the very same hotel complex and in the very same lecture hall at which this year's YUCOMAT was taking place, which at the time belonged to the Nuclear Commission of Yugoslavia. Dragan Usković also mentioned that this particular part of the coast, lying between Herceg Novi and Igalo, called Topla (meaning "warm") because of its unique climatic conditions, attracted many extraordinary scholars. They include the famous poet and statesman Petar II Petrović Njegoš (1813–1851), who was educated in a small house near the Church of St. George and Savior, a few minutes' walk from the conference site, and the 1961 Nobel Laureate in Literature, Ivo Andrić, who lived and worked in a house almost bordering the hotel, which is now converted to a museum honoring his lifework.

Along with Dragan Usković's welcome address, the attendees were also formally greeted by the Vice-Presidents of the MRS-Serbia, Dejan Raković and Velimir Radmilović, as well as by the Chair of the International Advisory Board, Yury Gogotsi, and the MRS-Serbia member Petar Usković (Figure 3a). The opening ceremony was also dedicated to the presentation of prizes (Figure 3b). They included the prizes for the best oral and poster presentations from the last year's conference and for the best doctoral thesis defended between the two conferences. The recipients were Ievgen Solodkyi from the Kiev Polytechnic Institute and Marta Tavoni from the Italian National Research Council in Faenza for the best oral presentations; Aleksandra Gezović from the University of Montenegro, Eva Černa from the Brno University of Technology, Hubert Pasiowiec from the AGH University of Science and Technology in Krakow, and Marko Jelić from the University of Belgrade for the best poster presentations; and Jana Mišurović from the University of Montenegro for the best PhD thesis. The most notable prize, however, was that for the "lasting and outstanding contribution to materials science and engineering", which is given annually by the MRS-Serbia. This year's winner was Knut W. Urban, a professor at Aachen University and the former Director of the Institute of Microstructure Research at Forschungszentrum Jülich (1987–2010) as well as the former President of the German Physical Society. Knut also had the privilege of giving the first talk of the conference [3] (Figure 4a,b). In it, he described the magnum opus of his scientific career: the building of the world's first aberration-corrected transmission electron microscope (TEM). As he noted in the lecture, shortly after Ernst Ruska invented the TEM in 1931, a magnifying instrument that should theoretically be able to image materials with an atomic resolution, reports started to pop up explaining why this resolution would not be possible to reach. In 1936, Otto Scherzer deduced the most important of these limitations: the spherical aberration of the electromagnetic lens, caused by the shorter focal length of the lens in its peripheral region than in its central region. This intrinsic defect could not be solved by the simple etching of the peripheral region because this would lower the resolution of the microscope. It took over 60 years before Knut and his colleagues built the first aberration-corrected TEM [4], a feat they achieved with the use of unround diverging lenses consisting of multipoles. One reason why it took such a long time before this challenge was overcome was because the path toward the solution proposed by Ernst Abbe and followed ever since by a number of researchers turned out to be an impasse. Namely, because of Gauss' law of magnetism, one of four Maxwell's equations, it is fundamentally impossible to construct diverging lenses from round magnetic fields and thus compensate for the spherical aberration of a converging lens by combining it with a suitable diverging lens, which Abbe and his followers attempted to achieve. This was an important historical remark, warning about the dangers of unquestionably submitting to the ongoing trends in science. Diverging from the trends, in contrast, more often than not presents a prolific path forward [5–7]. Other important philosophical points of view, which become imminent when one descends to the quantum scale, were presented during the talk, one of which was the cautionary tale against taking the ball-and-stick images of the atomic structure of materials obtained using aberration-corrected TEM as literal. It was said that only by processing these images via iterative solutions of the relativistically corrected Schrödinger equation can the more realistic, albeit also more ambiguous at all times, picture be obtained.

Figure 3. (**a**) Chair of the International Advisory Board, Yury Gogotsi welcoming the audience together with the MRS-Serbia member Petar Uskoković, the MRS-Serbia President, Dragan P. Uskoković, and the MRS-Serbia Vice-Presidents, Velimir Radmilović and Dejan Raković (seated, left to right). (**b**) Petar Uskoković presenting the award for a best oral presentation at last year's YUCOMAT to Marta Tavoni from the Italian National Research Council in Faenza.

Figure 4. (**a**,**b**) Knut W. Urban, this year's winner of the award for the lasting and outstanding contribution to materials science and engineering, giving the first lecture of the conference.

3. Plenary Lectures

Plenary lectures were well received by the audience and, albeit there were only 17 of them, they encompassed a wide scope of interest at the frontier of today's materials science and engineering. These presentations were divided into five sessions, where the first two dealt tentatively with the general properties in new materials and nanotechnologies; the third session dealt with bionanosciences; the fourth one focused on energy technologies; and the fifth one was about composite structures and sustainable development.

The first plenary session opened with the talk by Chad Mirkin from Northwestern University in Evanston, Illinois [8] (Figure 5a). The subject of this presentation touched upon the perennial dream of materials scientists to be able to choose a set of properties in a material and then derive precise conditions for the synthesis of one such material [9]. If first principles and any other theoretical frameworks were abandoned in search of a model that would enable one such correspondence, miniaturization combined with the ability to achieve high-throughput reactions with varied parameters could still offer an empirical path to the fulfillment of this dream, or so was at least implied by Mirkin's talk. Specifically, his group developed a nanoscale scanning probe lithography method to fabricate nanoreactors enabling the preparation of what Mirkin called "megalibraries" containing 5 billion distinct inorganic nanomaterials, including alloys of up to four different phases. Mirkin described the effort to develop high-throughput platforms for structural, catalytic, and optical characterization so as to match the high rate of megalibrary synthesis. Eventually, this setup strives to provide that missing link between the infinite possible structures and properties attainable by physicochemical combinations of elements of the periodic table and the knowledge of conditions leading to their synthesis. It was intriguing to think what would happen to theory if the ultrafast high-throughput synthesis would succeed in being paired with equally rapid and ultrasensitive characterization; namely, would it be left out of the picture and would algorithms from the domain of artificial intelligence be allowed to invent their own means for data parsing and extracting meaningful information from the overabundance thereof?

Figure 5. Plenary lectures by Chad Mirkin (**a**) from Northwestern University; Lei Jiang (**b**) from the Chinese Academy of Sciences; Paul Weiss (**c**) from the University of California in Los Angeles; Sam Stupp (**d**) from Northwestern University; Vladimir Torchilin (**e**) from Northeastern University; Anne Andrews (**f**) from the University of California in Los Angeles; Yury Gogotsi (**g**) from Drexel University; and Yuntian Zhu (**h**) from the City University of Hong Kong.

The next plenary talk in the first session was by Lei Jiang (Figure 5b) from the Chinese Academy of Sciences in Beijing, who described research whose starting point was astonishment over the extraordinary energy efficiency of biological reactions, such that, as he pointed out, ultralow energy consumption is coupled to high-efficiency energy conversion [10]. A simple numerical calculation of the energy intake of different organs in the human body showed that this ultralow energy consumption is possible in a physical system only if it contains ultralow-resistivity matter transport in nanochannels, where the classical Newtonian diffusion cedes place to a directional, collective motion of ions or molecules. The quest for such superfluidic and superwettable, quantum-confined transport, according to Lei, will drive the progress in neuroscience, in future quantum computing technologies, and in a series of disruptive technologies that still lie beyond the horizon.

The talk by Paul Weiss from the University of California in Los Angeles (Figure 5c) followed and it dealt with interfaces [11], specifically those between different nanostructures. His research on this topic sprang from the observation that if the properties of conventional semiconductor devices crucially depend on the contacts between their components, so must the properties of nanoscale "devices of the future" also depend on the interfaces. Energy band alignment, minimally disruptive connections, and control of spin and heat were some of the effects demonstrated to occur by precise control of interfaces on the nanometer scale.

After the invocation of nearly geological timescales in discovery in materials science in the talk by Knut W. Urban, a concordant case was mentioned in the talk by Markus Antonietti from the Max Planck Institute of Colloids and Interfaces in Germany [12], which ended the first plenary session. The case in question was about Justus Liebig's synthesis of polymeric graphitic carbon nitride from urea under the conditions mimicking the early Earth in 1832. This extremely chemically stable material has just recently been discovered to be a catalyst capable of activating CO_2 or photochemically turning water into hydrogen, oxygen, or more chemically complex compounds. Antonietti talked about an array of modifications of this graphitic carbon nitride, including the highly crystalline and stable ones with HOMO potentials down to 2.7 eV, but also those with positive work functions suitable for single-atom deposition and those acting as potential new semiconductors in organic electrical devices.

The second plenary session was supposed to open with a talk by Zhong Lin Wang from Georgia Institute of Technology, who postponed his talk for the next year [13]. The lecturer was to describe the efforts that went into the discovery of the triboelectric nanogenerator by his group in 2012. The device is based on coupling triboelectrification and electrostatic induction in order to convert mechanical energy into electric power and has found application in self-powered systems in a variety of fields, from medicine to environmental science to the Internet of Things. Instead, the second session opened with a talk by John Rogers, yet another presenter from Northwestern University after Mirkin. Rogers described the means for creating complex 3D structures on a variety of scales via geometric transformation of preformed 2D precursor micro- and nanostructures and/or devices into 3D layouts. This transformation utilizes substrate-induced compressive buckling, where the bonding type and distribution, the thicknesses involved, and other parameters control the final configurations. This lecture was followed by that of another plenary lecturer who studies interfacial control as a means to fabricate functional materials: Dongyuan Zhao from Fudan University [14]. He showed how processes at the interface, be they microemulsion self-assembly, evaporation-driven assembly, interface-driven orientation, interfacial dynamic migration, or others, could be used to create functional mesoporous materials with oriented multilevel architectures. Such materials are typified by controllable mesoporous channels, open frameworks, and interesting fluid dynamics, and they adopted a variety of structures, ranging from core–shell to multishell to bouquet posies to hemispheres to Janus particles to multipods to many other multilevel microarchitectures. The second session ended with the presentation by Arumugam Manthiram from the University of Texas in Austin, who talked about the modifications to the chemistry of lithium batteries in order to improve on their cost, energy and power density, cycle life, safety, and environmental impact [15]. Specifically, his approach involved substituting cobalt with nickel in the cathode and replacing the graphite anode with a lithium-metal anode but also designing electrolytes for compatibility with these new chemistries, given the observed thermal, air, and cycle instability at high nickel contents in the cathode and poor cycle life of the lithium-metal anode.

The third plenary session opened with a presentation by the last of the three plenary lecturers from Northwestern University: Samuel Stupp (Figure 5d). Like the other two presenters from this institution, Stupp also talked about advanced methods of synthesis [16,17]. Unlike Mirkin and Rogers, however, Stupp advocated the self-assembly of supramolecular structures as the route toward the most transformative soft materials, especially when inspired by biology and aided by computational methods. Materials inspired by the photosynthetic machinery of plants; dynamic robotic materials capable of transducing different sources of energy into mechanical actuation and driving the locomotion of objects; and biomaterials undergoing controlled supramolecular motion to heal neurological tissues were case studies described in his talk.

Following the two interesting historical examples of the delay between the discovery of a physical entity and the onset of research on its application, one presented by Urban and another by Antonietti, the third example was referred to in the talk by Vladimir Torchilin (Figure 5e) from Northeastern University in Boston [18]. Torchilin described the earliest reports on neutrophil extracellular traps (NETs) from 1996 and only the recent rise of interest in them as potential drug delivery targets and modulators of innate immunity. Released by neutrophils, NETs are 10–15 times larger than their parent cells and are composed of processed chromatin bound to cytoplasmic proteins. Torchilin explained that the current targets for drug delivery reside on the surface of the cells or occasionally are extracellular matrix antigens, while NETs may act as more convenient extracellular targets, given their congregation around various sites of pathologies and universal character, unlike that of the antibodies. The lecturer described liposome- and micelle-based systems for the delivery of DNAses to NETs to destroy them, while also delivering drugs for treating conditions tied to the NET formation, such as thrombosis or cancer. The third plenary session ended with the lecture by Anne Milasincic Andrews (Figure 5f) from the University of California in Los Angeles, which was about the fabrication of microscopic field-effect transistor sensors functionalized with ssDNA receptors for small molecule sensing and implantation into tissues [19]. Her talk also covered the accomplishments in fabrication of nanoribbon transistors on hard and flexible polymeric substrates for wearable brain and spinal cord sensors of serotonin, dopamine, pH, and temperature.

The fourth plenary session started with a talk by Prashant Kamat from the University of Notre Dame in Indiana [20]. Solar cells based on metal halide perovskite quantum dots were shown to be capable of reducing the energy payback time from 3 years for the current generation of silicon photovoltaics to less than a year when the thin film design was pursued. With this approach, low-temperature processing was enabled, thus reducing the fabrication cost. All the while, the conversion efficiency was maintained at a level greater than 26%, matching the power conversion efficiency of conventional silicon solar cells. Metal halide perovskite quantum dots were supposed to be one of the central protagonists of the talk by Andrey Rogach from the City University of Hong Kong, which was to follow, if it were not for the typhoon in Hong Kong, which prevented the lecturer from participating this year. Rogach's talk, specifically, was to thematically cover metal halide perovskite nanocrystals as a new type of efficient light-emitting diodes (LEDs) [21]. However, their stability issues require interfacial design, which the lecturer's group achieved with proper surface passivation, specifically by the introduction of inter-layer amine-terminated carbon dots or multiamine chelating ligands. The environmental point of substituting Pb in these perovskite nanocrystals with cerium, bismuth, or tellurium, without compromising the efficiency of photoluminescence, was also meant to be addressed.

The talk by Yury Gogotsi from Drexel University (Figure 5g) addressed MXenes [22], a family of 2D materials with the general chemical formula of $M_{n+1}X_nT_x$, where M represents a transition metal (Ti, Mo, Nb, V, Cr, etc.), X is either carbon and/or nitrogen

(n = 1, 2, 3, or 4), and T_x represents surface terminations. Gogotsi pointed out that only 50 MXene compositions have been reported to date, whereas chemical and microstructural versatilities of these materials are limitless. These materials offer a combination of superb properties at the mechanical and optical levels. One major point addressed was that because charge carriers in these materials are always close to the surface, their interaction with electromagnetic waves could reversibly alter the surface termination and lead to various switchable properties. Another plenary lecturer that also came from the city of Philadelphia, albeit from a different institution, University of Pennsylvania, was Aleksandra Vojvodić, whose talk ended the fourth plenary session and was, coincidentally, also largely about MXenes, the study of which her group approaches from a different, theoretical angle [23]. Specifically, she described the computational prediction of MXene catalysts for electrochemical hydrogen production and MXene materials for hydrogen storage but also properties in other materials, emphasizing the role of interfaces, nanostructuring, dimensionality, undercoordination, and surface termination.

The final, fifth plenary session began with the talk by Yuntian Zhu (Figure 5h), who, like Weiss and Zhao before him, also focused on the need for precise interfacial control. To exemplify this, heterostructured materials containing heterogeneous zones of intense variations in physical properties were described. These zones where counterintuitive synergetic effects commonly take place can lead to mutuality of properties that cannot be predicted by the rule of mixtures, such as, for example, simultaneous ultrahigh strength and ductility. The session followed with the lecture by Hamish Fraser from Ohio State University in Columbus, who demonstrated the existence of a comparatively uncommon deformation mechanism in the new titanium alloy Timetal®407 (Ti-0.85Al-3.9V-0.25Fe-0.25Si-0.15O, wt.%) [24]. The analysis was based on comparison of the microstructures of Timetal®407 and older Timetal®6-4 under deformation. Although both materials exhibited slip steps on the surface due to dislocation mobility under stress, the former alloy was also shown to deform by alpha/beta interface sliding, explaining the significant ductility observed during the ultrahigh strain rate testing experiments. The presentation by Mario Ferreira from the University of Aveiro in Portugal followed, in which the lecturer described novel protective nanostructured coatings with self-healing properties [25]. The idea to study these coatings came from the observed drawbacks of directly mixing corrosion inhibitors with coating formulations. These drawbacks include the decreased barrier properties of the coating, the diminished activity of the inhibitor, the osmotic blistering of soluble inhibitors, or environmentally pernicious leaching into the environment, all of which have adverse performative and safety consequences. To cope with these limitations, smart, environmentally responsive nanocontainers were developed that release entrapped corrosion inhibitors in response to local pH changes or the presence of corrosive species.

The fifth plenary session concluded with the talk by the author of this report, Vuk Uskoković, for whom this was the 19th YUCOMAT conference to present at, albeit for the first time virtually because of an unfortunate series of flight cancellations and restrictions. In this lecture [26], I shared a provocative idea that poverty in terms of the inaccessibility of resources for research could be a great driver for the derivation of inventive scientific concepts. To illustrate this idea, I used my personal story of having once abundant resources for research and personal income reduced to nil over five years ago, in the spring of 2018, after which I continued to do research to the best of my capabilities, despite the financial hardships, turning backyards [27,28], kitchens [29,30], bedrooms [31], playgrounds [32], lagoons [33], and open air [34] into laboratories and also engaging in a range of national and international scientific collaborations [35–41]. When the wittiness and groundbreaking potential of research prior to and after this transition were compared, not only the greater inventiveness of the latter but also its greater potential for translation to products accessible to people in poor countries of the world were seen, justifying the choice for the title of the talk: Materials Science of and for the Poor. The talk, as such, refuted the premise that the quality of research in sciences is directly proportional to the amount of funding it has received and was supposed to act motivationally to developing countries, which, according to the author [42,43], should seek an autonomous path that suits their technological potentials and cultural identities best instead of copying the paths and trends dominant in the so-called developed countries.

4. Sponsor Presentations

Four lectures by the sponsors were presented at this year's YUCOMAT, the first two of which were by David Swanson [44] and Jonathon Brame [45] from the U.S. Air Force Office of Scientific Research in London, UK, and the U.S. Army Research Laboratory, respectively, who presented information on various research grant funding opportunities to the attendees. The third sponsor lecture was provided through Croatian Mikrolux and it was by Martin Suchanek from the Czech division of TESCAN, who described TESCAN's TRUE X-Sectioning TESCAN Rocking Stage, which implements a high-current plasma focused-ion beam (FIB) for scanning electron microscopy (SEM) characterization of materials on cross-sectional scales of hundreds of micrometers, larger than those suitable for the commonly used FIB-SEM workflows [46]. The fourth sponsor lecture was presented by Teodora Andrejić from Analytics, who described a number of different experimental devices provided by this company.

5. Regular Oral Presentations

Around 50 or so regular oral presentations were held and all of them were interesting and curiosity-provoking, yet a few stood out with their content to this author.

Among talks on nanocomposites and electrochemical phenomena in materials, Jovan Lukić from the University of Belgrade presented the results of a search for transparent electrodes based on silver nanowires [47]. Because electrodes based on these nanowires alone are typified by low adhesion, high surface roughness, and low thermal, electrical, and chemical stability, all of which hinder their applicative potential, nanocomposites were fabricated comprising silver nanowires and zinc oxide. The synthesis was complex, consisting of welding the nanowires in the first step so as to decrease the junction sheet resistance and then spin-coating the oxide phase multiple times. Next, Adrian Radoń from the Institute of Non-Ferrous Metals in Gliwice mentioned the limitations of metals as electromagnetic interference-shielding components, primarily their low corrosion resistance and poor mechanical flexibility, for which reason he dug into composites in search of better materials for this kind of application [48]. Out of a series of ferrites added to an acronytrile butadiene styrene matrix, the best performing was the one consisting of ultrafine $CoFe_2O_4$ nanoparticles deposited on the surface of magnetite nanoparticles with the shape of truncated octahedra, which resulted in the highest reflection losses.

Regarding the lectures on photoactive materials, Natalia Majewska from the University of Gdansk lectured on a search for materials with an efficient broadband near-infrared luminescence [49], which led her group to Ga_2O_3 activated by Cr^{3+} ions, a material that they also doped with Sc and Al. Interestingly, while the undoped sample displayed only one luminescence center, the Sc-doped sample displayed two distinct emission spectra when taken at different time intervals, suggesting that the distribution of the crystal field strength spanned over the crossing point of the ^2E and $^4T_2$ states and that the Cr^{3+} luminescence centers were located in both strong and weak crystal fields, as the result of which both broadband and line emissions were observed even at low temperatures.

As for the talks on crystal growth and self-assembly, the one by Eric Hill (Figure 6a) from the University of Hamburg was a celebration of morphological and surface chemistry anisotropy of nanoparticles, demonstrating their essential role in controlled nanoparticle assemblies [50]. It was argued that layered materials with charged basal surfaces are particularly well suited for controlling the crystal growth habit of materials. Correspondingly, it was shown how the surface chemistry of edge and basal surfaces dictates the outcome of self-organization of particles at liquid–vapor interfaces. Self-assembly was also the subject of a talk by Patrick Gane from Aalto University in Helsinki, where he showed how mixing similarly sized cellulose nanocrystals and calcium carbonate nanoparticles results in the self-assembly of multilevel hierarchical structures whose features depend on the particle size and concentration ratios [51]. Further, at high cellulose weight ratios, the assembly was controlled by the intercellulose hydrogen bonding, whereas at high carbonate concentrations, the process was dominated by the flocculation of the latter particles. The assembly of nanoparticles, however, gained a whole new perspective in a talk by Ajith Manayil Parambil from Jawaharlal Nehru University in New Delhi (Figure 6b), where the researcher described how fluorescent carbon dots decorated with silver nanoparticles could be used as building blocks for molecular logic gates [52]. Specifically, two different forms of biogenic carbon dots, thiol-functionalized and acid-functionalized, were used to construct a logic library representing 15 fundamental logic gates and their combinational operations for multistimulus-responsive computing.

The talks by Marcel Herber from the University of Hamburg and Mohsen Beladi-Mousavi (Figure 6c) from the University of Bordeaux both dealt with the deposition of nanoparticles on the surfaces of microbubbles. The former researcher specifically talked about the use of microbubbles to pattern colloidal particles on substrates by attracting the particles, in his case MXenes, via Marangoni convection onto microbubbles formed at the interface between the substrate and the colloidal suspension and then onto the substrate through van der Waals interactions [53]. The latter researcher, in contrast, described the trapping of graphene sheets onto the ultrathin walls of air bubbles, thus creating surfaces with an asymmetrical reactivity for use in bipolar electrochemistry [54].

Relative to studies on solidification of materials, dissolution of materials has been an understudied phenomenon. However, Aleksandr Kryshtal from the AGH University of Science and Technology in Krakow presented interesting findings from in situ monitoring of melting of Sn and Sn-Ge nanoparticles under Cs-corrected TEM [55]. It was shown that a disordered phase a few monolayers thick nucleates at the surface of the particles at a temperature approximately 25 °C lower than the melting point, before expanding toward the core with increasing temperature and eventually turning the whole nanoparticle liquid. This disordered surface layer of heterogeneous density and thickness, however, was not truly liquid; rather, its density was an intermediate between the densities of the solid phase and of the liquid phase.

As far as sintering was concerned, the work by Marek Faryna from the Polish Academy of Sciences in Krakow contributed to the understanding of sintering of yttria-stabilized zirconia, a key material for solid oxide fuel cells due to its high ionic conductivity and chemical resistivity [56], showing the curious formation of texture in the 1500–1550 °C range, with the overabundance of (001) planes, which would become severely underrepresented at sintering temperatures above 1550 °C.

High-entropy alloys were well represented at the conference, as in the lecture by Andreja Jelen (Figure 6d) from Jožef Stefan Institute in Ljubljana [57]. In these alloys, at least five different metals are mixed in a relatively simple crystal lattice, but physical properties are usually not simple compositional averages of the physical properties of the constituent phases. In her case, the $AlCoFeNiCu_x$ ($x = 0.6$–3.0) alloy, surprisingly, developed magnetic softness due to the exchange-averaging of magnetic anisotropy and also exhibited nil magnetostriction coefficient because of the compensation of magnetostrictions of different signs at particular volume fractions, prompting the researcher to propose the material as a supersilent one, that is, inaudible to the human ear.

Figure 6. Oral presentations by Eric Hill (**a**) from the University of Hamburg; Ajith Parambil (**b**) from Jawaharlal Nehru University; Mohsen Beladi-Mousavi (**c**) from the University of Bordeaux; Andreja Jelen (**d**) from Jožef Stefan Institute; Francesco Colella (**e**) from the Italian National Research Council in Lecce; Eva Černa (**f**) from the Brno University of Technology; Sung Ho Yang (**g**) from the Korea National University of Education; and Ewa Mijowska (**h**) from the West Pomeranian University of Technology.

Concerning the talks on mechanical processing and characterization, Olha Zvirko from the Karpenko Physico-Mechanical Institute of the National Academy of Sciences of Ukraine in Lviv presented findings on the treatment of low-alloyed steel with mechanical pulses leading to severe plastic deformation [58]. After either unidirectional or multidirectional modes of the treatment, the microhardness of the top nanocrystalline layer formed was more than 5 times greater than that of the matrix. However, the multidirectional treatment mode led to a slightly higher microhardness of the surface layer due to its lowering the grain size more and also facilitating the generation of dislocations more when compared to the unidirectional deformation. Next, in the talk by Thomas Kalpakoglou from the Cyprus University of Technology, the presenter objected to the existence of standards for mechanical characterization of metal foams only in the uniaxial compressive mode and went on to perform similar standardization under tension and shear [59].

Among the many interesting talks on biomaterials, Francesco Colella (Figure 6e) from the Italian National Research Council in Lecce described the reasons why biologists need electrodes for in situ measurements of potassium ion concentrations in living cells and tissues. Then, he went on to describe his group's design of a ratiometric fluorescent microsensor for K^+ live imaging at sub-30 mM concentrations, employing dispersible silica microparticles in the design [60]. Leila Motiei from the Weizmann Institute of Science in Israel described a method for decorating bacterial surfaces with self-assembled synthetic receptors based on modified DNA duplexes [61]. This enabled her group to create bacterial probes that could label different types of cancer cells with distinct colors, with the goals extending farther, toward the possibilities of endowing bacteria with new properties, such as the ability to glow with different colors depending on the internal conditions but also adhere to surfaces and interact with proteins or cells. Another intricate biomedical concept was presented by Manuela Calin from the Nicolae Simionescu Institute of Cellular Biology and Pathology in Bucharest, whose group developed lipid nanoemulsions loaded with a cocktail of specialized pro-resolving lipid mediators and covered with macrophage membranes, then delivered them in vivo by intravenous administration [62]. The general idea behind this project was that atherosclerosis owes its conditions to failed inflammation resolution and since the nanoparticles managed to accumulate in the region of atherosclerotic lesions in the aorta of Apo-E-deficient mice, the clinical prospect of this biomaterial was obvious. Eva Černa (Figure 6f) from the Brno University of Technology described phage therapies for multidrug-resistant bacterial infection but also pointed out that phages must be effectively delivered to the wound site using a suitable carrier [63]. The approach her group followed was based on delivering phages targeting *S. aureus* using gum Karaya-based injectable hydrogels. Almira Ramanaviciene from Vilnius University in Lithuania lectured about the different means for functionalizing noble metal and metal oxide nanoparticles with biomolecules to enhance the analytical signal of immunosensors [64]. Sung Ho Yang (Figure 6g) from the Korea National University of Education in Chungbuk lectured about biomineralization studied on laboratory scales [65] and advocated for the use of hydrogels as media instead of water, given the slowed ion diffusion, which is beneficial for regulating the crystallization phenomena and producing interesting structures that are otherwise difficult to produce in physiological aqueous solutions.

In the realm of soft materials, Amrita Chatterjee from Ghent University in Belgium was planning to introduce the conference attendees to limitless opportunities dormant in covalent organic frameworks, a novel class of porous crystalline polymers whose organic building blocks are linked covalently and topologically to form ordered structures [66], but her talked ended up being canceled. A specific interesting approach was where organic monomers with various HOMO/LUMO potential donor–acceptor properties were combined to optimize the energy alignment of these frameworks. In a similar domain, Francesco Ruighi from the Italian National Research Council in Lecce lectured about the quest for electrofluorochromic materials with a tunable fluorescence intensity, which took his group to D-π-D donor–acceptor diarylamino-based conjugate compounds exhibiting a twisted intramolecular charge transfer under visible light excitation [67].

A series of talks presented at the special symposium on MXenes in living systems described the newest results on characterization of this relatively new type of material for versatile biological responses. As usually happens in the early stages of analysis of such responses [68], results were contradictory. On one hand, Lucia Delogu from the University of Padua in Italy intended to report on the excellent biological and immune compatibility of MXenes [69] as well as the ability to inhibit monocytes and reduce the release of pro-inflammatory cytokines, alongside the antiviral activity of 2D carbides, nitrides, and carbonitrides as exemplary MXenes against SARS-CoV-2. Maksym Pogorielov (Figure 7a) from Sumy State University in Ukraine concordantly reported on high biocompatibility and antibacterial potential of $Ti_3C_2T_x$ MXenes immobilized inside a polycaprolactone matrix [70]. The same MXene was shown in a presentation by Carmen Lorena Manzanares from Ludwin-Maximilians University in Munich to be able to quench a fluorescent dye positioned between 1 nm and 8 nm from the surface [71], following a distance dependency of d^{-3}. She concluded that MXenes could be used as short-distance spectroscopic nanorulers for measuring biomolecular processes at a distance range that conventional energy transfer tools do not normally access. In contrast, Sergiy Kyrylenko (Figure 7b) from Sumy State University demonstrated an evident genotoxicity of the same chemistries of MXenes in the comet assay of B16F10 murine melanoma cells [72] at concentrations ranging from 6.25 to 100 µg/mL. Interestingly, no talk tackled the "cradle to gate" life cycle of MXenes, including the comparatively high energy demand and environmental footprint of raw material extraction and manufacturing stages in the production of these materials [73].

Figure 7. Oral presentations by Maksym Pogorielov (**a**) and Sergiy Kyrylenko (**b**) from the Sumy State University in Ukraine in the special symposium on MXenes in biology that took place in the small hall.

With regard to 2D materials other than MXenes, Ewa Mijowska (Figure 6h) from the West Pomeranian University of Technology in Poland talked about borophene and its derivatives as one of the newest members of the 2D family of materials, describing its synthesis, oxygen-bonding characteristics, and potential for acting as a potent electrocatalyst in the oxygen evolution reaction [74]. Finally, the talk by Željko Mravik from the University of Belgrade went on to describe an interesting synergy reached by ion beam irradiation of graphene oxide and 12-tungstophosphoric acid in their nanocomposites [75]. First, unlike graphene oxide, tungstophosphoric acid was much more sensitive to the radiation dose, as with increasing structural modification, bond breaking was first induced, giving a higher catalytic activity in the hydrogen evolution reaction, whereas further irradiation resulted in an increased interconnection of polytungstate species, thus diminishing the catalytic activity. As for the synergy, it was observed in terms of the higher capacitance of irradiated composites as compared to graphene oxide alone, the reason being the reduced electrolyte flow along the ion tracks due to the interaction of polytungstate with defect sites on graphene.

6. Poster Presentations

Over 100 posters were scheduled for presentation at the conference, in the morning hours of Tuesday to Thursday, and many of them appealed to the visitors with their scientific value.

Among presentations on photoactive and electrochemical materials, following the oral presentation by Željko Mravik, in which the need for optimization of ion beam irradiation of a material such as graphene oxide nanocomposite was shown, the poster presentation by Marko Jelić from the University of Belgrade arrived at the same point [76]. In this study, monoclinic bismuth vanadate ($BiVO_4$), one of the most promising photoanode materials for photoelectrochemical water splitting, was subjected to heavy Xe ion irradiation in the effort to alleviate the poor charge transfer properties due to the high electron–hole recombination rate. However, the excessive irradiation caused considerable amorphization and also increased the amounts of V^{4+} and oxygen in the form of hydroxide, especially at higher fluences, having a notable negative effect on the photoelectrochemical oxygen evolution reaction. Mariia Stanitska from the Kaunas University of Technology in Lithuania described research attempting to reduce and simplify the complicated multilayer guest–host/co-host structures that state-of-the-art thermally activated delayed fluorescence-based organic LEDs assume [77]. The problem encountered was the limited choice of emitters with a perfect combination of required electronic properties, especially for blue LEDs, where device efficiencies drop considerably when one or more functional organic layers are omitted from the structure. However, as this study showed, by engineering donor–acceptor-type molecules based on a 1H-1,2,3-triazole core, structural simplifications of this type of LED are possible. Sergii Ubizsky presented the research by Shpotyuk et al. from the O.G. Vlokh Institute of Physical Optics in Lviv, in which the high-energy milling of melt-quenched arsenoselenide alloys in dry and combined dry–wet modes was compared. According to the findings, the former mode gave rise to positron traps with lower defect-specific lifetimes corresponding to multivacancies in the arsenoselenide matrix, as opposed to the latter mode, which produced positronium-hosting holes with a significantly longer lifetime, stabilized mainly in the polyvinylpyrrolidone environment [78]. Leonid Vasylechko from the Lviv Polytechnic National University in Ukraine missed the meeting but still described in the proceedings an exciting work on calcium and strontium dialuminates, $(Ca/Sr)Al_4O_7$, with a monoclinic grossite-type structure as rare-earth hosts for luminescent applications [79]. Specifically, it was observed that the incorporation of Cr^{3+} ions was owed to the peculiarity of the $CaAl_4O_7$ grossite structure in terms of the presence of two non-equivalent tetrahedral positions of Al^{3+} ions and one position of Ca^{2+} ions in the pentagonal bipyramidal coordination, which are suitable for replacement. Similarly, the crystal structure of apatites ($M1_4M2_6(PO_4)_6OH_2$) possesses two distinct sites for metal ions, the columnar (M1, 4f) and the hexagonal (M2, 6h), where atoms in M1 positions are surrounded by nine oxygen atoms (three O(1), three O(2), and three O(3)), while atoms in M2 positions are surrounded by six oxygen atoms (O(1), O(2), and four O(3)) and one OH^- ion [80]. Here, the cations with a higher electronegativity have a greater affinity for covalent interactions and for bonding with hydroxyl groups [81], and this problem of understanding the affinity for selective accommodation at these two sites became critically important a month or so before the conference began, when it was reported that superconductivity at room temperature in lead apatites would be observed if Cu substituted Pb only on M1 sites and not on M2 sites in the $M1_4M2_6(PO_4)_6O_2$ structure [82]. In any case, this duality of sites of metal ions may be an intrinsic explanatory principle underlying the excellent propensity of not only grossites but also apatites for accommodating practically every element of the periodic table inside their structure [83].

Two presentations at this year's YUCOMAT tackled the subject of superconductivity explicitly, both as posters. Jovan Šetrajčić from the Academy of Sciences and Arts of the

Republic of Srpska in Banja Luka pointed out that the mechanism of superconductivity has not been figured out to date, with the biggest difficulty stemming from the highly anisotropic and translatory non-invariant nature of this physical phenomenon [84]. With the assumption that the answer to the question of superconductivity in oxide ceramics must be sought in the phonon sub-system, in the elementary charge carrier sub-system, and in the interaction between these two sub-systems, Šetrajčić derived a theoretical model of high-temperature superconductors, concluding that the electronic gas in ultrathin superconducting films is a less ordered system, lying closer to the equilibrium state than it is in comparative bulk structures. Moreover, it was observed that the theoretical samples, in agreement with the experimental data, display the competing existence of superconducting and normal regions in them. In the presentation by Oksana Kvitnitskaya (Figure 8a) from the B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine in Kharkiv, trigonal $PtBi_2$, a Weyl semimetal, was analyzed for electron–phonon interactions by Yanson point contact spectroscopy and a substantial increase in the T_c was observed, from 0.6 K in the bulk to 3.5 K in point contacts, also indicating the electron–phonon interaction mechanism of Cooper pairing [85].

As for presentations on sintering, Ievgen Solodkyi tackled one of the fundamental problems in this form of materials processing, using WC-Co composites as the model [86]. In this material, namely, the fracture toughness and strength maxima are observed only when WC grain sizes are less than 100 nm. With densification during sintering, however, the reactivity of ultrafine grains prompts their growth beyond the submicron range, compromising the mechanical characteristics. As a path toward the solution, having studied the mechanistic aspects of the process, Solodkyi's group used high-speed densification in the liquid phase, where the sintering time of porous compacts to full density did not exceed 150 s, with no coarsening observed in the process. Next, Veljko Savić from the Institute for Technology of Nuclear and Other Mineral Raw Materials in Belgrade described the process of formation of sintered glass foams using glass from landfills and sugar beet factory lime as the foaming agent, praising the material for its high insulation capacity, low specific weight, durability, and potential to promote sustainable development [87].

Further, Aleksander Učakar from the Jožef Stefan Institute in Ljubljana described research on optimizing the sintering of hexagonal ferrites, which have recently emerged as an alternative to Sr and Ba ferrites as the world's most-produced permanent magnetic materials, which themselves have been alternatives to rare-earth magnets because of the latter's harmful environmental footprint and problematic supply [88]. The goal of this research was to optimize the sintering process to a degree that it would enable fast and affordable sintering of 3D printed models with complex geometries. Another poster presentation about ferrites was delivered by Agnieszka Ciuraszkiewicz (Figure 8b) from the Institute of Non-Ferrous Metals in Gliwice, who praised these materials for a combination of properties that include saturation magnetization reaching up to 90 emu/g, high electrical resistance, low dielectric losses, and excellent chemical stability, and then went on to describe the synthesis of various core–shell nanostructures, where magnetite acted as the core and different ferrites as the shell [89]. According to the findings, the solvent identity, alongside the temperature, had a pivotal influence on the material properties, as exemplified by a case where Fe_3O_4@$NiZnFe_2O_4$@$CoFe_2O_4$ nanocomposites synthesized in triethylene glycol as a low-boiling medium had almost 100 times lower values of the imaginary part of the dielectric permittivity, ε'', than their counterparts synthesized in benzyl ether as a high-boiling medium. Tymon Warski from the same institute described the optimization of the heat treatment of rapidly quenched, amorphous $Fe_{77.3}Co_5Nb_3Cu_{0.7}B_{14}$ ribbons, deriving core power loss minima from coercivity vs. temperature dependences, which were twofold: the first minima corresponded to the amorphous phase at the onset of crystallization of α-Fe at 350 °C, while the second one corresponded to the onset of the crystallization of the hard magnetic boride phases at 470 °C [90]. Another presentation on magnetic materials that stood out was by Igor Đerđ from the Josip Juraj Strossmayer University of Osijek in Croatia, who reported on the NiO-CeO_2 mixed oxide system, where the magnetic behavior differed significantly from that of CeO_2 and NiO nanoparticles alone [91]. While CeO_2 is diamagnetic, but turns ferromagnetic on the nanoscale because of the mixed valence of Ce^{3+}/Ce^{4+} and intrinsic oxygen vacancies [92], NiO is anti-ferromagnetic, yet the mixed system was shown to be ferromagnetic.

In the realm of additive manufacturing, Bartosz Jozwik (Figure 8c) from the Institute of Non-Ferrous Metals in Gliwice described a work on copper-based alloys for selective laser melting, an additive manufacturing technology also known as laser powder bed fusion, where powdered alloys are melted and solidified in a layer-by-layer fashion [93]. The rationale for the choice of copper was that while the bulk of current research concentrates on iron- and titanium-based alloys for this type of manufacturing, copper alloys have been studied less because of the problems associated with high heat conductivity and low laser energy absorption. Hubert Pasiowiec from AGH University of Science and Technology in Krakow was intending to demonstrate how repeated cycles of melting and solidifying of the melt pools of Inconel 625 superalloy during the laser powder bed fusion process of additive manufacturing generate high residual stress in the material, affecting its subsequent recrystallization temperature [94], but his presentation had to be cancelled.

For those who were curious how the deliberate production of oxygen vacancies in materials could augment their performance must have been disappointed because two poster presentations that explicitly tackled this subject were submitted as abstracts but ended up not being presented. One of them was by Vojtech Marak from the Brno University of Technology, who was going to describe research inspired by the literature-supported idea that oxygen vacancies, which his group generated by annealing in reducing atmospheres [95], might lead to improvements in the functional properties of a lead-free $BaTiO_3$ piezoceramic doped with Zn. Another study where oxygen vacancies were intentionally created, albeit using citrate groups, to boost the material performance was supposed to be presented by Natalia Kobylinska from the A.V. Dymansky Institute of Colloid and Water Chemistry of the National Academy of Sciences of Ukraine in Kyiv [96]. In her case, the material was a layered double nickel–iron hydroxide with a hydrotalcite structure, which she proposed as a new adsorbent. Interestingly, the capacity to remove Pb(II) and Sr(II) steadily increased with an increase in the atomic ratio of nickel to iron, reaching 99.8% removal efficiency at equilibrium for Ni_4Fe double hydroxide.

Among other presentations on adsorbents and scavengers, Daniela Šojić Merkulov from the University of Novi Sad in Serbia pointed out that pharmaceuticals count amongst the most concerning pollutants [97] and went on to use photocatalysis to remove tolperisone hydrochloride from water, with the contribution of reactive species changing in the following order: $OH^{\bullet}_{free} > h^{+} \gg OH^{\bullet}_{ads} > e^{-}$. It was also shown that tolperisone harms barley by hindering water uptake, whereas barley is protected from stress by high genetic variability. To remove doxycycline from the environment, Nataliia Stolyarchuk from the Chuiko Institute of Surface Chemistry of the National Academy of Sciences of Ukraine in Kyiv used a composite comprising a magnetite core and a polysilsesquioxane shell formed by either bridging silanes with phenylene groups or functional silanes with amino or mercapto groups or their combination [98]. It was shown that the bifunctional shell led to the highest adsorption, equivalent to the sum of the adsorptions in mg/g for the two systems containing each of the shell chemistries alone. Kateryna Hubenko (Figure 8d) from the Leibniz Institute for Solid State and Materials Research in Dresden reported on $GdVO_4:Eu^{3+}$ nanoparticles as effective scavengers of hydrogen peroxide, where the decomposition reaction is driven by the electron capture by pentavalent vanadium ions, which are subsequently reduced to 4+ and 3+ states [99].

Figure 8. Poster presentations by Oksana Kvitnitskaya (**a**) and Olga Kazakova (**e**) from the National Academy of Sciences of Ukraine; Agnieszka Ciuraszkiewicz (**b**) and Bartosz Jozwik (**c**) from the Institute of Non-Ferrous Metals in Gliwice; Kateryna Hubenko (**d**) from the Leibniz Institute for Solid State and Materials Research in Dresden; Veronika Zahorodna (**f**) from the Materials Research Center in Kyiv; Anastasia Konieva (**g**) from the Sumy State University in Ukraine; and Veronika Polakova (**h**) from the Brno University of Technology.

In the set of presentations on self-assembly and supramolecular chemistry, Polina Pisklova from the Institute for Scintillation Materials of the National Academy of Sciences of Ukraine in Kharkiv presented on J-aggregates as highly ordered nanostructures formed from non-covalently coupled dyes, such as cyanines, porphyrins, perylenes, and others [100]. The translational symmetry of molecules inside such aggregates ensures that the electronic excitations of individual molecules are delocalized, producing the characteristic J-band, which results from electric dipole transitions into the low-energy edge of the Frenkel exciton band. Because of this unique ordering and intrinsic optical activity of molecules, these aggregates can create a number of interesting properties, ranging from very narrow absorption to fluorescence line widths to large extinction coefficients to giant third-order optical nonlinearities to exciton superradiance. Further, as shown by Pisklova's presentation, the interaction of molecularly distinct J-aggregates can produce energy transfer at a minimal distance, while the interactions of surface exciton–polaritons in the aggregates can augment the fluorescence intensities and lifetimes for both aggregates simultaneously. Jiri Brus from the Czech Academy of Sciences in Prague studied chain-walking polymerization, a new means for producing dendritic structures [101]. To optimize the polymeric architecture and topology, polyethylenes were synthesized using an α-diimine palladium catalyst, which promoted chain-walking more, and an α-diimine nickel catalyst, which promoted the chain-walking less. The crystalline domains were typically surrounded by proto-crystalline, semiamorphous phase, with this weakly branched interface extending gradually to the hyperbranched gel-like fractions. Further, Olga Kazakova (Figure 8e) from the Chuiko Institute of Surface Chemistry of the National Academy of Sciences of Ukraine in Kyiv described the increase in solubility of curcumin by two orders of magnitude after its incorporation into micelles composed of a cationic dimeric surfactant, which proved to be a more effective solubilization agent than its monomeric counterparts [102]. Moreover, although the keto tautomer was thermodynamically more favorable in an aqueous solution, the interaction with the micelles stabilized the enol tautomer, confirming the active role that micelles have in the physical structures and chemical processes of reactions proceeding under their confines [103,104].

Considering surface processing, Vanessa Barvinska from NoviNano Lab in Lviv described the work on using femtosecond laser pulses to create periodic surface structures and thus fabricate superhydrophilic surfaces, which could be applied as self-cleaning surfaces, anti-fogging coatings, or heat transfer surfaces due to their extreme wetting properties [105]. Veljko Đokić from the University of Belgrade studied the formation of titanium-based nanotubes on the surface of an ultrafine-grained Ti-13Nb-13Zr (wt.%) alloy by electrochemical anodization and concluded that the nanotube layer was oxide in composition and that it could either decrease or increase the corrosion resistance of the material, depending on the nanotube layer morphology [106]. Kristina Mojsilović, also from the University of Belgrade, argued in favor of plasma electrolytic oxidation as an alternative to classical anodization for the formation of protective coatings on the surfaces of metals and alloys. She specifically described a case of the parallel treatment of Nb and Ti surfaces, where different outcomes were observed after identical treatments: namely, while the Nb surface became rougher at longer processing times, the surface of Ti remained smooth. Both surfaces, however, underwent phase transformations at prolonged treatment times: while an anatase-to-rutile phase transformation was detected on the Ti surface, a pseudohexagonal-to-tetragonal Nb_2O_5 phase transition was observed on the surface of Nb [107].

Among the presentations on mechanical materials and processing methods, Pavel Zabrodin from the B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine in Kharkiv subjected the fine-grained AE21 alloy (Mg-1.7Al-0.66Ce-0.36La-0.23Nd-0.18Mn-0.05Pr) to uniaxial tension in the temperature range of 0.5–400 K, observing that the yield strength varied slightly with temperature, while the ultimate strength and the strain to failure had a strong dependence on temperature [108]. The ultimate strength, specifically, increased monotonically as temperature decreased from 400 to 0.5 K, while the strain to failure decreased from 20 to

3% as the temperature dropped from 400 to 4.2 K and then increased to 4.5% with a further drop down to 0.5 K. Yury Semerenko from the B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine in Kharkiv was intrigued by the compromise intrinsic to high-entropy alloys [109]: namely, the increase in their strength caused by a decrease in the grain size tends to be accompanied by a detrimental decrease in plasticity and impact strength. To overcome this fundamental issue, his group followed the ongoing trend of working with non-equilibrium multiphase non-equiatomic high-entropy alloys. In such materials, plasticity does not need to be compromised with an increase in strength because of mechanisms such as those where plasticity is induced by twinning or by phase transformation. The study demonstrated that doping can be used to adjust the contribution of these two competing mechanisms of plasticity. Moreover, Elena Tabachnikova from the same institution studied the effects of carbon addition to the high-entropy alloy $Co_{25-x}Cr_{25}Fe_{25}Ni_{25}C_x$ (x = 0, 1, 3 at.%) and showed that the effects are considerable and dependent on whether the samples are coarse-grained or nanocrystalline [110]. In the former, the microhardness increased monotonically with the carbon content, but in the latter, the microhardness peaked at x = 1 at.%, the reason being the drop in the dislocation density and an increase in the grain size as the carbon content increased from 1 to 3 at.%. The mechanisms of hardening were also shown to be different depending on the grain size, involving solid solution and dispersion hardening in the coarse-grained sample and a decrease in the grain size, as per the Hall–Petch relation, and an increase in the dislocation density, as per the Taylor relation, in the nanocrystalline sample.

As for cements, Katarina Šter from the Slovenian National Building and Civil Engineering Institute in Ljubljana described the work on carbonation curing of concrete, a rapid chemical reaction between calcium-bearing phases and CO_2, which improved the compressive strength of the cements [111]. Temperature was an equally important parameter in the process, as it affected the type of hydration in the cement. Among the posters on catalysis, Brigita Hočevar from the National Institute of Chemistry in Ljubljana described a rigorous study of testing a dozen different metals supported on different substrates for the production of adipic acid from bio-based sources [112], concluding that, first of all, water is a poor choice of solvent per se for this type of catalytic reaction and that methanol presents a more effective choice and, second of all, that the choice of the support is crucial, as out of a number of different combinations of metals and substrates, only rhenium on the carbon support yielded satisfactory results.

MXenes were abundantly represented by poster presentations in addition to the lectures. Marius Olariu from the Technical University of Iasi in Romania demonstrated manipulation of MXene flakes via dielectrophoresis using a set of screen-printed interdigitated electrodes patterned on a polyester substrate [113]. Like the nature of the solvent tackled in the aforementioned poster presentation by Agnieszka Ciuraszkiewicz, the aging time presents one often overlooked parameter of materials syntheses and storage processes. As pointed out by Oksana Gutsul from the Bukovinian State Medical University in Ukraine, aging of a dispersed solution of Ti_3C_2 MXenes in N-methyl-2-pyrrolidone had an absolutely crucial effect on their electrical conductivity, as illustrated by its significant increase accompanied by a change in the shape of the Nyquist plots after 50 days of storage [114]. This increase correlated with changes in the size of the MXene flakes and in their chemical composition, as concluded by the band shifts and new bands appearing in the Raman spectra. Another interesting effect reported was that of the speed of spin-coating deposition of the material onto gold interdigitated electrodes for electrical measurements. Here, with an increase in the spin speed from 100 to 900 rpm, the electrical conductivity of the films decreased, while the charge transfer resistance and the capacitive resistance of the double layer increased by no less than three orders of magnitude.

Among carbon materials other than MXenes, Viktor Zoryansky from the B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine in Kharkiv studied C_{60} saturated with either hydrogen or nitrogen [115].

The mechanism of intercalation changed at around 300 °C and 420 °C, respectively, transitioning from physisorption to chemisorption and then, at saturation temperatures higher than this, yielding new chemical compounds: $C_{60}H_x$ and $(C_{59}N)_2$. The independence of the integrated radiation intensity on temperature in $C_{60}H_x$ was used to conclude about its glassy state, whereas the temperature dependence observed in $(C_{59}N)_2$ led to a newly observed low-temperature quenching of fluorescence in this material. Jana Petrović from the University of Belgrade described her group's attempt to find the solution for the high recombination rate of electrons and holes that limits the practical application of g-C_3N_4, a potential visible light photocatalyst [116]. The approach involved treatment with H_2SO_4, which was expected to increase the specific surface area, obtain more active sites, anchor the electronegative -HSO_3 groups to boost the electron migration and enhance the charge separation, exfoliate bulk g-C_3N_4 into the nanosheets, and expand the band gap (~2.7 eV). Evgen Len from the Kyiv Academic University in Ukraine missed the meeting but still reported in the proceedings on research conducted with the goal of reducing the work function of cold cathodes for field emission, which acts as a potential barrier that needs to be overcome by the external field [117]. Toward that end, his group looked at the intercalation of graphene sheets with rubidium atoms, noting that the side faces were particularly convenient for accommodation of this alkali metal. Also, it was observed that defects in graphene flakes play a positive role in the sense that they contribute to the orientation of a portion of graphene sheets perpendicularly to the surface, thus acting as sites of an effective field emission.

Considering poster presentations on nanocomposites, other than those already mentioned, Miray Çelikbilek Ersundu from the Yildiz Technical University in Istanbul proposed the use of dual quantum dot-doped glass nanocomposites as a host/waveguide material for luminescent solar concentrators, which are designed to increase the energy conversion efficiency of photovoltaic systems [118]. Simple synthesis protocols, machinability, scalability, recyclability, durability, and intrinsic optical activity were mentioned as advantages compared to organic dyes commonly used as solar concentrators. The "less is more" maxim found its definite antipode in the presentation by Zoran Samardžija from the Jožef Stefan Institute in Ljubljana, who reported on the upgrade of the working electrodes for screen printing with polyaniline, carbon nanotubes, and Pt nanoparticles on vulcan carbon and Au nanoparticles [119].

As for inventive synthesis methods, Aleksandra Gezović from the University of Montenegro in Podgorica engaged in the challenge of figuring out the way to prepare the mixed phosphate–pyrophosphate $M_4Fe_3(PO_4)_2P_2O_7$ (M = Li, K and Zn) as a potential new mixed-polyanion cathode material for metal-ion batteries [120] through direct synthesis and solved it by producing the sodiated form of the compound first, that is, $Na_4Fe_3(PO_4)_2P_2O_7$, and then subjecting it to a fast electrochemical exchange of Na^+ ions with Li^+, K^+, or Zn^+. Veronika Zahorodna (Figure 8f) from the Materials Research Center in Kyiv described a novel method for an ultrarapid synthesis of MXenes based on self-propagating combustion [121]. Unlike the more traditional methods for the synthesis of these 2D materials, this high-temperature method was said to circumvent the use of more expensive pure transition metals or their carbides, as it could produce equally high-quality MXenes from cheaper transition metal oxides. Cristina Ciomaga from Al.I. Cuza University in Romania described a method for making porous $Ba_{0.85}Ca_{0.15}Ti_{0.90}Zr_{0.10}O_3$ by burning poly(methyl methacrylate) (PMMA) particles as the pore-forming agent and then provided theoretical calculations concluding that highly specific and anisotropic porosity distribution may define equally specific strain–stress distributions, leading to superior piezoelectric and pyroelectric figures of merit [122]. Vlad Lukacs from the same institution observed that most studies on $BaTiO_3$ ceramics were performed for critical grain sizes of around 1 μm, where superior properties have been found, and went on to run a study trying to determine how electrochemical properties vary depending on the grain size [123].

Science often evolves prolifically when it probes unquestioned answers and not only when it pursues unanswered questions. In the realm of biomaterials, toothpastes represent such materials that are being almost universally used but with few studies analyzing the potentially detrimental effects of some of their components. In the research presented by Miroslav Đoćoš from the University of Novi Sad in Serbia, covarine, taking the form of 200-micron beads and being a common component of whitening toothpastes, was analyzed upon its mixture with saliva in a microfluidic mixer and in computational simulations, trying to understand the formation of microfilms on enamel surfaces [124].

Complementing the special oral session dedicated to the biological characterization of MXenes, a number of poster presentations tackled the same topic. Among these, Anastasia Konieva (Figure 8g) from Sumy State University in Ukraine presented the results of a study on functionalization of Ti_3C_2 MXenes with CEACAM1 antigen for melanoma cell targeting, having recognized that while normal melanocytes are CEACAM1-negative, melanoma cells, on the contrary, exhibit high levels of CEACAM1 expression [125]. MXenes, in this case, were proposed as a material facilitating photothermal conversion and eradication of tumors recognized and bound to by the functionalized MXenes. Kateryna Diedkova from the same institution presented the results on the development of electrically conductive polycaprolactone-$Ti_3C_2T_x$ MXene composites as cardiac patches [126]. Optimization studies showed that depositing MXenes atop the electrospun polymer nanofibers in bilayers provided the best conditions for cellular attachment and proliferation, along with exhibiting a mild antibacterial effect. Anastasia Denysenko, also from Sumy State University, described the compositional and histological analysis of dura mater specimens from patients with ectopic calcification, showing that the content of Mg, unlike that of most other ions analyzed, was 10 times higher in calcified samples than in the controls [127]. Zhanna Klischova from the same institution confirmed the genotoxicity of $T_3C_2T_x$ MXene in melanoma cells through an additional set of controls [128], while her colleague, Anton Roshchupkin, showed that the size of the MXene flakes correlates inversely with the degree of DNA fragmentation [129] and Milena Yalyzhko showed that freshly prepared MXenes displayed a more intensive genotoxicity than aged, oxidized ones as well as that MXene flakes of sufficient size, reaching 2 or 3 microns, displayed no genotoxicity [130]. Viktoriia Korniienko, also from Sumy State University, showed that the bactericidal effect of UV exposure on *E. coli* in suspensions was severely delayed when Ti_3C_2 MXenes were present, the reason being the strong absorption of UV rays by MXenes, which effectively protected the bacteria against the disinfectant radiation instead of producing additional reactive oxygen species to synergistically combat the bacteria [131].

As for other notable presentations from the biomaterials section, Veronika Polakova (Figure 8h) from the Brno University of Technology described the synthesis of smart poly(lactic acid) capsules stabilized with chitosan polymers of different molecular weights and loaded with copper nanoparticles, which were released in response to alkaline pH of the infectious environment due to the electrostatic repulsion intrinsic to the polymeric chains [132]. Anna Yanovska from Adam Mickiewicz University in Poznan described her group's work on synthetic ZnO-Au nanohybrids for use as electrochemical immunosensors for the detection of *Listeria monocytogenes* [133]. Anton Popov from Vilnius University in Lithuania also described research whose goal was to develop ZnO nanostructures for immunosensors and whose motivation was to continue discovering potentials for application in this material with high exciton-binding energy and band gap tunability in the range from 2.1 to 3.5 eV but also a high value of the isoelectric point (IEP ~ 9.1–9.5), which makes the immobilization of biomolecules on the surface feasible [134]. Antonella Bandiera from the University of Trieste in Italy described the biomimetic synthesis of the analogs of elastin, the main structural component of vertebrate tissues subjected to continuous cycles of expansion and contraction, using the exon 23–24 amino acid sequence of human elastin as the basic monomer to be repeated, namely VAPGVG, before encountering the problem of immune response elicitation in animal models used to evaluate the biocompatibility of the material [135]. For this reason, the so-called "universal" elastin-like polypeptide was developed, for which the amino acid sequence was derived by aligning several vertebrate elastin sequences and selecting the most evolutionarily conserved one. Dejan Raković from the University of Belgrade developed a theoretical model for assessing the biological influence of non-ionizing electromagnetic radiation, also known as electromagnetic smog, in wide frequency bands [136], calling for a more widespread discussion about the non-thermal effects of radiation across all bands on human health.

7. Social Events

Social events, as in every previous YUCOMAT, were versatile and neatly dispersed throughout the conference. The most numerous of these social events were coffee breaks, which separated the hours-long lecture sessions. During these breaks, a variety of beverages were served for the attendees, who could continue to chat about science (Figure 9a). Monday night was dedicated to the cocktail party, where bottomless drinks were served in a relaxed setting (Figure 9b). On Thursday afternoon, the attendees also had a chance to go on a boat ride across the Boka Kotorska Bay and visit a few tourist attractions along the way. In addition to these social events, poster sessions (Figure 9c), which were held in the early morning hours from Tuesday to Thursday, also provided a good opportunity for the attendees to get together and connect. Meanwhile, a gala dinner was held to honor the plenary presenters on Wednesday night. The credit for coordinating these events as well as numerous other technical and informal specificities of the meeting goes to the conference organizing team (Figure 9d), which included the chairpersons, Đorđe Veljović and Zoran Jovanović, the conference secretary, Jasmina Jevtić, the organizing committee members, Vuk Radmilović, Veljko Đokić, Sonja Jovanović, Aleksandar Dekanski, and Željko Radovanović, and the technical committee members, Željko and Jelena Rmuš Mravik, Vukašin Ugrinović, Tamara Matić, Marija Milivojević, Jana Petrović, Jovan Lukić, Nemanja Barać, and Marko Jelić.

Figure 9. Glimpses into social scenes during a coffee break (**a**), the Monday night cocktail party (**b**), the Thursday morning poster session (**c**), and the conference desk during usual working hours (**d**).

In (**a**), the University of Montenegro and the University of Belgrade participants and their company are catching up with each other during a break: Jana Mišurović, Nikola Đurković, Nikola Grudić, Veselinka Grudić (standing, left to right), Sonja Kastratović, Igor Miljanić, Aleksandra Gezović, Minea Kapidžić, and Milica Vujković (seated, left to right). In (**b**), the University of Belgrade participants enjoy the cocktail party: Nemanja Barać, Vukašin Ugrinović, Jovan Lukić, Veljko Đokić, Željko Radovanović, Tamara Marić, and Jana Petrović (left to right). In (**d**), the conference secretary, Jasmina Jevtić, and the members of the technical and organizing committees of MRS-Serbia, Željko Mravik, Sonja Jovanović, Jelena Rmuš Mravik, and Jovan Lukić, pose (left to right) for the camera.

8. Closing Ceremony

The winners of the competition for the best oral and poster presentations, as decided on by the awards committee, were announced at the closing ceremony. Rankings of any form in a discipline that is as subject to taste as science is must be trivial, but this tradition serves as a good motivator for the young scientists and also an attractor that draws the crowd to the lecture hall to hear the closing remarks. The MRS-Serbia member Đorđe Janaćković had the honor of presenting the awards to the winners this year, which are donated jointly by the MRS-Serbia and the MRS-Singapore. The winners included Natalia Majewska from the University of Gdanska, Francesco Ruighi from the Italian National Research Council in Lecce, Adrian Radoń from the Institute of Non-Ferrous Metals in Gliwice, Marcel Herber from the University of Hamburg, and Tamara Matić from the University of Belgrade (Figure 10a, left to right) in the best oral presentation category and Kristina Mojsilović from the University of Belgrade, Tymon Warski from the Institute of Non-Ferrous Metals in Gliwice, Kateryna Diedkova from Sumy State University in Ukraine (Figure 10b, left to right), Brigita Hočevar from the National Institute of Chemistry in Ljubljana, and Zuzana Kadlecová from the Brno University of Technology in the best poster presentation category. Željko Mravik from the University of Belgrade won the competition for the best PhD thesis (Figure 10c). All the winners are waived the conference fees for the first following YUCOMAT. The farewell addresses were given first by the Chair of the International Advisory Committee, Yury Gogotsi, who praised the conference organizers for a tremendous achievement, and then by the MRS-Serbia President, Dragan P. Uskoković, who expressed his hope that everybody enjoyed the conference and would bring home valuable memories and return to this site again (Figure 10d). The closing ceremony ended with a party and free drinks for all, to celebrate yet another successful YUCOMAT and draw the curtain on it in good spirits (Figure 11).

Figure 10. Best oral (**a**) and poster (**b**) presentation awardees and the best PhD thesis awardee (**c**). The awardee names, affiliations, and identities in the photographs are described in the text. The participants were addressed during the closing ceremony by the MRS-Serbia President, Dragan P. Uskoković, Chair of the International Advisory Board, Yury Gogotsi, the MRS-Serbia member Đorđe Janaćković, and the Vice-President of MRS-Serbia, Dejan Raković ((**d**), left to right).

Figure 11. Farewell party accompanying the closing ceremony. The President of the MRS-Serbia, Dragan P. Uskoković, is chatting with the Conference Organizing Committee members Veljko Đokić and Sonja and Zoran Jovanović.

9. Conclusions

An overwhelming success, this year's YUCOMAT provided a window into the latest trends in materials science and engineering and was a gratifying event for all the participants who expressed their opinions on it to the organizers. Next year's YUCOMAT, the 25th since the conference was first organized in 1995, has been scheduled for 2–6 September 2024 and will take place concomitantly with the 13th World Round Table on Sintering organized by the International Institute for the Science of Sintering. All are welcome to get onboard for yet another exciting encounter with the best materials science has to offer, in a scenic setting that never fails to inspire.

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