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Editorial for the Special Issue on the Occasion of Reinhard Pippan's 70th Birthday: Celebrating a Legacy of Innovation and Excellence in Material Science

On the occasion of Reinhard Pippan's 70th birthday, it is our profound honor to dedicate this special issue to a personality whose contributions have significantly advanced our understanding of material science. Reinhard Pippan, retired vice director and group leader at the Erich Schmid Institute, has devoted his career to exploring the mechanical properties of metals, alloys, and composites. His work spans the realms of plastic deformation, fatigue and fracture, as well as micro- and nanomechanics, with a strong focus on severe plastic deformation (SPD), novel nanostructured materials that can be synthesized by this, as well as uncovering their sometimes rather unexpected deformation and failure mechanisms.

Reinhard's journey in academia began with his education in physics at the Technical University Graz, culminating in a PhD from the Montanuniversität Leoben in 1982 under the supervision of Prof. H.P. Stüwe. His career has been predominantly associated with the Erich Schmid Institute (ESI) of Materials Science of the Austrian Academy of Sciences, where his research has flourished. Reinhard has been instrumental in introducing discrete dislocation mechanics to fracture and fatigue, leading to a deeper understanding of fatigue crack propagation and fracture processes. For the first 20 years of his career, this remained his main focus and led to significant impacts in these fields.

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Driven by the idea that nanostructured materials should possess outstanding fracture and fatigue properties, Reinhard entered the field of severe plastic deformation (SPD) with the intention to synthesize such materials at ESI. Even though in the early days several SPD-techniques, such as equal channel angular pressing (ECAP), were already available at ESI, he early recognized the advantages of high pressure torsion for basic research work, rooted in the simplicity of the process and the extensive accessible parameter space. At the beginning, his main interest targeted the microstructural processes leading to ultrafine and nanograined structures, the limits of grain refinement and the underlying structure property relationships. His further advancements in the HPT-technology have created pathways to synthesize novel materials, for example super-saturated solid solutions, placing his SPD group at the forefront of this rapidly evolving field. Additionally, Reinhard placed great efforts in the upscaling of the process and made first steps into industrial applications of the HPT-technique.

Due to the limited material quantities available by SPD deformation and the need to better understand the uncommon mechanical properties of ultrafine-grained and nanostructured materials, the scope of Reinhard's research in the last twenty years extended into the micro- and nanomechanics domain, where his pioneering visions in micromechanical testing have set new standards. This encompasses for example the discrete dislocation based deformation of confined sample volumes and most notably the field of miniaturized fracture mechanics, where his vast knowledge in conventional fracture experiments and analysis laid out the foundation for transferring these experimental procedures to micron scales. In some cases, it took us years to finally realize ideas and experimental concepts that Reinhard had quickly sketched on an old machine punch card, his favorite notepad.

This special issue is an attempt to feature a collection of manuscripts that echo the diversity and depth of Reinhard Pippan's research interests. Topics range from high-pressure torsion and nanocrystalline materials to advanced characterization techniques and the role of microstructural elements in fatigue and fracture. But before briefly addressing some details of the articles in this special issue, we would like to share some notable details of the jubilate:

Personal Milestones and Academic Achievements

Born on October 29, 1954, in Klagenfurt, Austria, Reinhard Pippan has led a distinguished career marked by numerous accolades, including the Erich Schmid Award of the Austrian Academy of Sciences, the Wöhler Medal of the European Structural Integrity Society and the Tammann Gedenkmünze

of the German Society of Materials Science. His academic journey, from studying mechanical engineering at a technical high school in Klagenfurt, graduating in physics at the TU Graz in 1980, receiving his PhD in materials science at the Montanuniversität Leoben in 1982, to obtaining his habilitation in Solid State Physics at the Montanuniversität in 1991 and being promoted to Professor at the Montanuniversität Leoben in 2004, reflects a deep-rooted passion for understanding material behavior at fundamental levels.

Reinhard Pippan's tenure at the Erich Schmid Institute includes pivotal roles such as serving as long time vice director and twice interim director of the institute, navigating the institute well guided through difficult times. Further, he was head of the Christian Doppler laboratory for local analysis of deformation and fracture, and principal investigator of the ERC Advanced Grant USMS, the first (and still only) such prestigious grant that was granted to a scientist in Leoben. His work has garnered numerous significant research grants and produced over 600 publications, underscoring his prolific contributions to the field.

His scientific leadership is most clearly visible through the numerous invited and plenary lectures he has given at prestigious conferences across his research areas. Reinhard's dedication to securing research funding and his active participation in these projects underscores his ability to drive forward-thinking research and secure necessary resources to support groundbreaking studies. Furthermore, his success also enabled him to take on undergraduates, PhD students and post docs and send them with exciting novel results to conferences across the globe.

Impact on Young Researchers and the Scientific Community

One of the most remarkable aspects of Reinhard's career is his mentorship of young researchers, which both editors had the privilege to experience firsthand. His research team at the Erich Schmid Institute comprised numerous young scientists, most often funded through third-party projects, that would benefit from his extensive experience and guidance, academically and privately, being it over a beer in the workshop, a glass of red wine at his home, in the face of a rock climbing route, or during a skiing tour. Reinhard has always been an inexhaustible resource of positive ideas and inspiration. At this point we cannot forget to mention his cooking and baking skills. While Reinhard's wife, Sigrid, would frequently master the former, together they are a congenial duo when it comes to making 'Kärntner Kasnudeln', no matter whether for a group of 4 or 40 hungry students. And while the distant Corona was a challenge for all of us, it actually benefited Reinhard's baking skills, and the photo contest with Otmar over their newest sweets became legendary. Fueled by this incredible combination of scientific guidance, hospitality and friendship, many of his former students and postdocs have gone on to assume leading positions in European industries, international research institutes, and top universities. This mentorship highlights Reinhard's dedication to fostering the next generation of scientists and his substantial role in shaping the future of material science.

Highlighted Manuscripts in this Special Issue

The manuscripts in this special issue represents a wide array of topics that resonate with Reinhard Pippan's research themes, which we attempted to categorize into five areas, which is quite challenging due to their strong topical interrelation. These articles are contributed by invited experts in their field, and for simplicity we name in the following overview only the invited author but deeply thank the entire author-teams:

(i) HPT techniques and deformation

1) **Hyoung Seop Kim** [202301862] explores the fabrication of ultrastrong nanocrystalline Inconel 718 through powder high-pressure torsion and annealing, a testament to the advancements in material processing techniques. 2) **Kaveh Edalati** [202302267] delves into the high-pressure torsion processing of serine and glutamic acid, enhancing our understanding of mechanochemical behavior under extreme conditions. 3) **Roberto Figueiredo** [202400175] evaluates the scale-up processes in high-pressure torsion, addressing the challenges of translating laboratory-scale techniques to industrial applications. 4) **Xavier Sauvage** [202400265] discusses physical mechanisms, intrinsic limitations and future perspectives concerning the co-deformation of severely deformed multiphase metallic systems. 5) **Zenji Horita** [202400282] uses in-situ electrical resistance measurements to study phase transformations in pure titanium during severe plastic deformation. 6) **Roman Kulagin** [202400388] presents a continuum mechanics approach to describe cold welding of metals under shear. 7) **Terence G. Langdon** [202400477] reports on recent developments in the use of high pressures for the production of nanostructured materials. 8) **Oliver Renk** [202400578] critically discusses the saturation of grain fragmentation upon severe plastic deformation. 9) **Jürgen Eckert** [202400593] explores the refinement characteristics in FeTi-Cu_x composites with emphasis on localization and abrasion constraints. 10) **Marlene Kapp** [202400595] presents an in-depth analysis of the structural evolution during cyclic high pressure torsion to optimize fraction of low angle grain boundaries. 11) **Michael Zehetbauer** [202400692] examines the effect of V-content on the microstructure and mechanical properties of nanostructured $CoCrFeMnNiV_x$ high-entropy alloys.

(ii) Fracture and fatigue

1) **Brad Boyce** [202400150] offers insights into the toughness of interlocking metasurfaces, which could pave the way for novel material applications. 2) **Lorenz Romaner** [202400269] presents a high-throughput study on grain boundary and surface segregation together with their effect on grain boundary embrittlement 3) **Jaroslav Polák** [202400313] proposes a novel mechanism of intergranular fatigue crack growth, which is based on the damaging effect of extrusions and intrusions produced in the cyclic plastic zone of growing fatigue cracks. 4) **Tomas Vojtek** [202400367] critically discusses the frequently incorrect use of

2D plane stress solutions for free surfaces of cracked bodies and its significance for full field measurement techniques. 5) **Gunther Eggeler** [202400368] re-visits the high temperature strength of single crystal Ni-base superalloys and compares key characterization methods supporting alloy development and component design. 6) **Stefano Beretta** [202400447] reports on cyclic R-curve measurements of five structural alloys widely used in industry and underlines the necessity of new experimental techniques to measure long crack thresholds. 7) **Bernd Gludovatz** [202400541] investigates the fracture behavior of an ion-irradiated nanocrystalline TiZrNbHfTa refractory high-entropy alloy and highlights the impact of sample dimensional scale, microstructure, and ion irradiation. 8) **Balila Nagamani Jaya** [202400552] explores the origins of extrinsic size effects on the fracture resistance of thin copper sheets and finds that fracture is seen to be strain-controlled and not stress-controlled in the examined thickness regime. 9) **Magnus Ekh** [202400950] investigates the fatigue crack growth characteristics in pre-deformed pearlitic steel under multiaxial loading and reveals the interrelation between crack path and degree of pre-deformation.

(iii) Small scale testing

1) **Benoit Merle** [202400216] provides a detailed study on observing high-cycle fatigue damage in freestanding gold thin films by utilizing advanced bulge testing and TEM imaging techniques. 2) **Megan J Cordill** [202400251] investigates cyclic failure mechanisms in Cr-Au bilayers on polyimide, contributing valuable knowledge on interfacial dislocation processes. 3) **Christoph Kirchlechner** [202400357] offers insights into novel characterization approaches of dislocation structures and stress fields by intermitted 3D-tomography combined with in-situ Laue diffraction. 4) **Christian Motz** [202400406] focuses on a deeper understanding on GB migration by elucidating the impact and importance of shear driving forces, the free energy difference across grain boundaries and lattice dislocations. 5) **Gerhard Dehm** [202400720] reveals twinning induced orientation relationships of equi-atomic CoCrFeNi thin films on c-sapphire.

(iv) Novel materials

1) **Andrea Bachmaier** [202400253] examines the influence of severe plastic deformation on the magnetic properties of Sm-Co permanent magnets, linking mechanical processing with magnetic performance. 2) **Verena Maier-Kiener** [202400255] provides valuable insights into the phase transformations and ordering mechanisms in Pd-Cu-Ag-Ru alloys being crucial for applications in hydrogen membranes and electrical components. 3) **Praditpa Gosh** [202400341] explores the origins of recovery induced strengthening in a CoCrNi alloy. 4) **Oskar Paris** [202400353] examines the formation and temporal evolution of Al_3Zr dispersoids in an Al–Zn–Mg–Cu alloy by in-situ small-angle X-ray scattering to optimize size and number-density of those Al_3Zr dispersoids in the matrix. 5) **Ruslan Valiev** [202400394] discusses the significance of nanostructured titanium with ultrafine-grained structure as an advanced engineering material for biomedical applications. 6) **Peter Uggowitzer** [202400576] proposes a technique for metallographic visualization of small grain structures within Al–Mg–Zn–(Cu) crossover alloys. 7) **Heinz-Werner Höppel** [202400623] highlights the significant influence and positive effect of a pre-ageing treatment at lower temperatures on the subsequent artificial ageing treatment in Al-Mg-Si extrusion alloys. 8) **Mathias Göken** [202400266] tailors conductivity and mechanical properties through varying the layer thickness in Cu-Nb laminates fabricated by accumulative roll bonding. 9) **Thomas Siegmund** [202400270] uses scutoids as building blocks for load-carrying topologically interlocking material assemblies. 10) **Peter Uggowitzer** [202400776] further highlights in a perspective review the problems and limitations of hydrogen detection after 150 years of research on hydrogen embrittlement. 11) **Johann Riesch** [202400951] presents an overview on tungsten wires being used from lamp filaments to reinforcement fibers for composites in fusion reactors.

(v) Deformation mechansims

1) **Karsten Durst** [202400267] offers insights into grain boundary sliding in lamellar ultrafine-grained steels to be most likely carried by grain boundary dislocations. 2) **Roland Würschum** [202400426] gives a comprehensive review on high-precision dilatometry for the study of precipitation processes and micro-alloying effects in light-weight alloys. 3) **Megumi Kawasaki** [202400439] uses digital image correlation to analyze uniform deformation and necking in solid-state welded nanocrystalline aluminum. 4) **Jaroslav Pokluda** [202400535] examines how material microporosity affects the mechanical properties of a scaffold prepared by direct ink writing from pure titanium with dimensions typical for orthopedic implants. 5) **Christian Rentenberger** [202400536] demonstrates the extreme stability of ordered FeAl at very small grain sizes and indicates that the deformation behavior in brittle intermetallics can strongly depend on the grain size. 6) **Werner Skrotzki** [202400214] investigates microstructure and texture during high-pressure torsion of a nanocrystalline Au-13at%Pd alloy and explains the absence of texture changes by a grain boundary sliding mechanisms.

Each of these contributions not only advances the respective field, but also exemplifies the innovative spirit and scientific rigor that characterize Reinhard Pippan's work, and we sincerely hope that the jubilee will enjoy reading them.

Concluding Remarks

As we present this special issue, we extend our heartfelt congratulations to Reinhard Pippan. His scientific endeavors have not only enriched materials science in general and the lives of those he interacted with, but he also set a benchmark for future research and mentorship. Your legacy is one of relentless pursuit of knowledge, innovative thinking, and a commitment to scientific excellence, paired with humor and friendship. As we honor his 70th birthday, we also look forward to the continued advancements his personality will undoubtedly inspire in the years to come.

Happy 70th Birthday, Reinhard! May your journey of discovery and innovation continue to inspire and lead the way in materials science, rock climbing routes and best off-piste powder skiing slopes. This special issue can only address the former, where it stands as a testament to your enduring impact on

the field and your unwavering dedication to advancing our understanding of the complex interplay between materials' microstructures and their mechanical properties.

The manuscripts included herein not only celebrate your achievements, but also serve as a beacon for future research, reflecting the profound influence you have had on the scientific community. Your work has left an indelible mark, and we are privileged to honor you through this compilation of cutting-edge research.

With heartfelt best wishes on behalf of all your friends and colleagues,

Daniel & Toni

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Anton Hohenwarter is research assistant at the Department Materials Science of the Montanuniversität Leoben in Austria. His research interests concern mainly the mechanical behaviour of high performance materials with focus on the fracture and fatigue behaviour. He has been working together with Reinhard Pippan for many years and has been intensely involved in the severe plastic deformation activities regarding the structure - mechanical property relationships of ultrafine grained and nanocrystalline materials, as well as the further technical development and up-scaling of the HPT-synthesis process.