This first webinar arranged by Polymer Processing Society (PPS) at 7:30 AM New York time on January 15, 2021 focuses on additive manufacturing, an emerging area of research that has far-reaching influence in materials development, characterization, process modeling and integration, manufacturing, and above all niche applications and consumer appreciation. Six distinguished speakers from polymer community will share their novel contributions in additive manufacturing research.

The session will begin at 7:30 AM US Eastern Standard (New York) Time on Friday, January 15, 2021 and schedule six talks, 30 min each plus 5 min for questions. The title and abstract of each talk, speaker biographies are presented below.

**Talk 1: Arburg Freeformer for Medical Applications, Clemens Holzer, University of Leoben, Austria**

Within the CAMed project, medical products are manufactured by means of additive manufacturing (material extrusion). The manufacturing process is to be integrated into a clinical process chain. For this purpose, an exact data acquisition of the process-relevant information and other influencing factors as well as the transfer and archiving of this information is of particular importance. One way of guaranteeing consistent print quality is to qualify the materials, equipment and settings used. For this purpose, suitable parameters must be defined for material / system combinations. Such a qualification is to be presented on the basis of the Arburg plastic free-form technology. The various input parameters are compared by means of measured and visible output parameters in order to find material-specific parameters for this process. These parameters can be used for a successful and reproducible print or as output values for a further optimization process.

**Speaker bio:** Dr. Clemens H. Holzer is Head of Polymer Processing at the Department of Polymer Engineering and Science and full professor at Montanuniversitaet Leoben, Austria. He studied Polymer Engineering and Science at Montanuniversitaet Leoben, Austria and worked for 7 years at Huber+Suhner, Switzerland. His main research themes are injection molding, extrusion, compounding, recycling, additive manufacturing, simulation, and determination of material data.
**Talk 2: Powder Bed Fusion of Polymers - Technology Progress and Materials Research, Manfred Schmid, Inspire AG**

Additive manufacturing (AM) of polymers will be a future brick in the transformation to digital production (Industry 4.0). Among all 3D printing technologies, powder bed fusion (PBF) technologies such as laser sintering (LS), multi jet fusion (MJF) or high-speed sintering (HSS) are the primary technologies that transfer 3D printing (prototyping) to AM. PBF technologies are highly dependent on process-safe polymer powders in combination with QA measures for process and industrial production. These currently only partially available points are by far the greatest obstacles to the implementation of PBF in industrial production. Polymer powders must have a broad spectrum of specific properties in order to be reliably processed in the LS process. The complex combination of intrinsic and extrinsic powder properties requires complex material development processes and a thorough understanding of the overall system. In addition to the materials, the details of the fusion process are also decisive for the later component properties, since AM is a primary forming process. The great complexity of the material/process interaction is the reason for the lack of materials for industrial purposes. The contribution flash-lights the efforts in the development of further LS materials as well as the corresponding process and machine development in science and industry and tries to take a look into the future, what comes next.

**Speaker bio:** Dr. Manfred Schmid started his professional career in the R&D department of EMS-Chemie (Switzerland) and later moved to Empa to work on polymer analysis and bio-based polymers. For about 12 years he is head of R&D SLS of Inspire AG, a Swiss. His research interests focus on polymers in general and on polymer powders for powder bed fusion more specifically. He is part-time lecturer for polymer processing on different Universities for Applied Science in Switzerland.

**Talk 3: Conformal Additive Manufacturing of Soft Pressure Sensors, Jae-Won Choi, University of Akron**

This talk will introduce a conformal additive manufacturing process and polymeric materials for stretchable pressure sensors. Conformal additive manufacturing combines direct-ink writing and rheology-controlled inks to create a 3D structure on a freeform surface. In this process, a polymeric material is printed layer by layer by considering varying surface angles, where a series of algorithm for freeform slicing, offsetting, and tool path generation have been developed. With the developed process, stretchable and 3D-printable prepolymer for pressure-sensitive sensors have been developed. These prepolymer include an ionic liquid-based photopolymer for a pressure sensitive layer and a carbon nanotube-based composite material for electrode layers. The sensor is additively manufactured on a curved substrate, where the pressure sensitive layer is sandwiched between two electrode layers, forming a sensing element called “taxel.” Changes in voltage due to the sensor deformation are signal-processed to detect applied forces. Various 3D printed structures on a freeform surface as well as 3D printed sensors their applications will be introduced.
*Speaker bio:* Dr. Jae-Won Choi received B.S., M.S. and Ph.D. degrees in Mechanical Engineering from Pusan National University, Busan, Korea. He is now an Associate Professor in the Department of Mechanical Engineering at The University of Akron. His research interests include additive manufacturing, 3D printed smart structures, including sensors, actuators and electronics, 3D printed rubbers for insoles and tires, and low-cost binder-coated metal/ceramic for 3D printing. He is an associate editor of Additive Manufacturing journal.

Talk 4: Fused Filament Fabrication Melting Model, Tim A. Osswald, University of Wisconsin-Madison.

An analytical melting model inside the nozzle of a fused filament fabrication process is introduced. The model presents the limiting case scenario where the maximum melting rate is controlled by the applied force. Here, instead of having a nozzle filled with polymer melt, the melt is reduced to a melt film at the tip of the filament as it is pushed against the exit of the nozzle. The model uses a mode of melting that is governed by melting with pressure flow melt removal. The model includes effects of initial filament temperatures, heater temperature, applied force, nozzle tip angle, capillary diameter and length as well as rheological and thermal properties. The analytical solution is compared to experimental results. Furthermore, the model is used to assess the effect of nozzle tip angle, heater temperature and initial filament temperature on the melting rate within the nozzle. The comparison between the experiments and the model show that assumptions used for the model development are plausible, and that the model can be used to optimize the melting within a material extrusion additive manufacturing process, as well as predicting the performance of new materials.

*Speaker bio:* Dr. Tim Osswald is a Professor of Mechanical Engineering and Director of the Polymer Engineering Center at the University of Wisconsin-Madison. He received B.S. and M.S. in Mechanical Engineering from the South Dakota School of Mines and Technology and Ph.D. in Mechanical Engineering from the University of Illinois at Urbana-Champaign in the field of Polymer Processing. He published over 300 papers and authored books Materials Science of Polymers for Engineers, Polymer Processing Fundamentals, Injection Molding Handbook, Compression Molding, Polymer Processing Modeling and Simulation, International Plastics Handbook, Plastics Testing and Characterization, Understanding Polymer Processing, Polymer Rheology, and Discontinuous Fiber Reinforced Composites, all by Hanser.
Talk 5: Core-Shell Structured Filaments For Fused Filament Fabrication Three-Dimensional Printing To Maximize Mechanical Performance And Dimensional Fidelity To Digital Model, Miko Cakmak, Purdue University.

Fused Filament Fabrication (FFF) is an extrusion-based 3D-printing techniques in which molten polymer filament is extruded to produce 3D objects. Poor adhesion at filament bonding interfaces may lead to poor mechanical properties of FFF manufactured parts, and the highly non-isothermal FFF process leads to warping deformation and voids in the incompletely filled products.

In this presentation, we will discuss solution of this weakness by the use a core-shell structured filament in FFF 3D printing where exterior layer provides interfacial adhesion while core layer providing strength. Examples will be presented using Polycarbonate with high Tg core and low Tg shell yield improved bond strength at layer-interface and a synergistic improvement of impact properties while improving dimensional fidelity to the 3D digital model. Established processing window expansion using these strategies will be discussed.

Speaker bio: Dr. Miko Cakmak received his BS in Chemical Engineering from Technical University of Istanbul and MS and PhD in Polymer Engineering from University of Tennessee, Knoxville. He was one of the founders of Polymer Engineering Department at University of Akron and was Harold A. Morton Chair and Distinguished Professor of Polymer Engineering. He was the founding director of the National Polymer Innovation Center and developed roll to roll manufacturing lines for functional polymer films for a range of applications. He is currently the Reilly Professor of Materials Engineering & Mechanical Engineering at Purdue University.

Talk 6: Modeling of the Fused Filament Fabrication (FFF) Additive Manufacturing Process, J.F.Agassant, Emeritus Professor, MINES-ParisTech

The FFF Additive Manufacturing process is now widely used to produce polymer parts with complex 3D geometries. The presentation will show that process modeling can contribute understanding relationships between polymer data, process parameters and printing ability. It will focus on the two first steps of the process: (i) melting of the polymer filament in the liquefier, (ii) deposition of the polymer strand on the substrate. The aim of the lecture is to respond to the following questions: What is the maximum filament rate in the liquefier for a target and homogeneous temperature at the nozzle exit? What are the relationships between the printing parameters (polymer rate and temperature, printing head velocity, gap between the nozzle and the substrate) and the dimensions of the deposited strand as well as the applied pressure and interface temperature which govern the welding ability with the substrate. Finite elements solutions will justify easy handling of approximate solutions for predicting the melting ability in the liquefier, as well as the strand dimension and its welding ability with the substrate.
**Speaker bio:** Dr. Jean-François Agassant graduated from Ecole des Mines de Paris in 1972. He obtained a PhD from Paris VI university in 1980 on the modeling of the PVC calendering process. He initiated a research team at Center for Material Forming of Ecole des Mines de Paris in Sophia Antipolis devoted to polymer-processing modeling. He was appointed as Head of the Mechanical and Material Engineering Department of MINES-ParisTech (the new name of Ecole des Mines de Paris) between 2008 and 2016 and Head of MINES ParisTech in Sophia-Antipolis between 2011 and 2016. He is the co-author of a number of reference books on polymer processing modeling and author or co-author of 120 papers devoted to a broad area of subjects in Polymer Processing. He is currently the president of the Polymer Processing Society.