

## Lithography Should Not Be a Glass Bead Game

Harry J. Levinson  
Editor-in-Chief



Among the “inspired writings” for which Hermann Hesse won the 1946 Nobel Prize in Literature was his book, *Das Glasperlenspiel (The Glass Bead Game)*. The fictional world in which the novel takes place is one in the future, where scholars live in academic retreats, separated from the rest of society. Their central focus is a game, the Glass Bead Game, which some of the scholars pursue to the exclusion of all else. By the end of the novel, the protagonist has learned that true enlightenment can only be gained by engaging with the world outside of academic retreats.

While less isolated than the institutions conceived by Hesse, there is a degree to which contemporary colleges and universities are distanced from the rest of society. There are benefits to this separation, since this can foster environments in which researchers can explore ideas for which practical application may not be immediately apparent but could be useful in the future. Researchers can study problems in physics, chemistry, and technology without the need to deliver short-term results or meet impending deadlines for delivery of products to customers. A long-term perspective is particularly valuable now for semiconductor patterning, which requires understanding and insight into physical and chemical processes at scales only recently understood to be important to the performance of manufactured semiconductor devices. But as found by the protagonist in *The Glass Bead Game*, engagement with the world outside of academia is also important.

Engagement is where journals such as JM<sup>3</sup> play a role. There are many journals in which academicians can publish, but these are sometimes journals not frequently read by scientists and engineers in industry. On the other hand, lithographers and other engineers in industry involved with patterning technology regularly check JM<sup>3</sup> to see what are the latest developments in our field. Consequently, JM<sup>3</sup> is a useful conduit for researchers in academia to connect with people in industry.

Solutions for many issues facing lithographers could be facilitated by research into fundamental physical and chemical processes. For example, it is well known that the radiation chemistry of EUV resists is not driven directly from photoabsorption but is instead mediated by photoelectrons and secondary electrons. Such electrons have ranges of travel before being captured. If these electrons travel long distances, there may be too much image blur to achieve the desired resolution. Since we are talking about resolution requirements <10 nm, it has become important to understand electron transport at the nm and sub-nm level. Today, such detailed understanding does not yet exist, and it would be valuable to gain this insight in order to extend lithography. Phenomena such as the transport of low-energy electrons in solids are in need of greater understanding, and once better understood it is important that the learning be transmitted to people who can do something useful with it. Value to humanity requires that academicians not talk only to others in academia.

There are additional reasons for reinforcing connections between academia and industry. Since most scientists and engineers work in industry, students have an interest in being able to publish in a journal that is well-read by potential future employers.

There are institutional factors that reinforce having conversations confined within academia. Career advancement in a university necessarily requires that people prove their worth to others within academia, so many publications written by academicians are intended to influence other people in the academic world. SPIE, as a professional society dedicated to “bringing together engineers, scientists, students, and industry leaders to advance light-based science and technologies,” is a counter-force. SPIE’s *Journal of Micro/Nanopatterning, Materials, and Metrology* is well-aligned with the Society’s mission, providing a bridge between the academic and industrial worlds. For the semiconductor industry, as we move to features that are 10 nm or smaller, this is more important than ever. Publishing technical papers on topics relevant to lithography and patterning technology in JM<sup>3</sup> is a good way to keep research in science from becoming a Glass Bead Game!