

# 17<sup>th</sup> Rare Earth Magnets Workshop Review

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The 17<sup>th</sup> International Workshop on Rare Earth Magnets and their Applications [REM XVII] was held August 18-22, 2002 at the University of Delaware. This was the latest in the ongoing series of bi-annual meetings uniquely tailored to the rare earth magnets community. This year's Workshop was hosted by the University of Delaware and was chaired by George Hadjipanayis. Over 175 participants attended the meeting, and over 170 papers were submitted for presentation.

For those not familiar with the Workshop series, a little history is perhaps in order. The Workshops had their origins in the early 1970s when Karl Strnat, a prominent rare earths researcher at the Dayton Air Force Materials Laboratory in Ohio, first organized a gathering of scientists to discuss the then recently developed SmCo<sub>5</sub> permanent magnet materials. The acceptance of all papers, and the absence of parallel sessions ensured that all lectures could be attended if so desired.

In previous years there has been an additional Symposium that followed the Workshop, which focused on more fundamental and even theoretical research on rare earth magnet materials. This year, the Symposium was integrated into the Workshop so that work on fundamental research was nicely juxtaposed with processing and applications papers. A number of entities from within the industry sponsored the event, and while this evidently had some influence on the program content and scheduling of papers, it did not significantly detract from the overall meeting. This brief review focuses on some of the more industry-relevant work that was presented.

The meeting opened with a series of papers from attendees outlining the current status and apparent trends in rare earth materials development, and the markets into which they are sold and utilized – specifically Japan, China, the USA and Europe. It will be no surprise that, with the exception of the overview of the Japanese market, the increasing development of the Chinese magnet industry dominated predictions made for future trends in the USA, Europe, and of course China. The Japanese magnet industry appears to be focused on counteracting this trend through improvements at the higher performance end of the technical spectrum, including newly commercialized and improved manufacturing processes. Further suggesting that complete domination of the global magnet industry by China is not a foregone conclusion, a paper from Neorem noted that the use of Chinese Neo in complex applications such as motors has been limited due to quality issues.

In the past few years, the rate of increase in the performance of Nd-Fe-B materials, has slowed significantly. Werner Rodewald of Vacuumschmelze did announce at the meeting that his company had developed a 56.7 MGOe Nd-Fe-B material, achieved through some impressive improvements in material preparation and processing, as opposed to particularly special material compositions. As Mike Coey of Trinity College, Dublin has mentioned on numerous occasions, we are most likely at an end of the exponential growth of energy product of these magnetic materials. However, it was also good to see that there is still much research that continues in the older Sm-Co family of alloys.

The session on recent developments in permanent magnets generated a lot of interest. In particular, the paper from Electron Energy Corporation on Sm-Co alloys that perform well at high temperature, and from Aichi Steel on the use of a hydrogen processing technique called d-HDDR to produce anisotropic bonded magnets with energy products of up to 20 MGOe, were of significant interest. Magnequench also presented a paper on compression molded bonded magnets with energy products up to 22 MGOe.

As usual, David Howe of the University of Sheffield presented interesting work on the applications side of rare earth magnets. Of particular interest was a paper on permanent magnet gears with high torque densities. Matsushita Electric presented a nice paper on rare earth magnets in the small motor industry, including work on a new

highly flexible bonded magnet material. There were also good presentations from Hamilton Sundstrand, NASA and the US Air Force, who presented some of the challenges they face as users of permanent magnet materials in sometimes-extreme environments.

Regarding a possible "next great thing" on the materials front, there is much work being undertaken on nanocomposite materials, and there were various papers presented on the subject at the Workshop. The concept here is to marry the strong anisotropy of a material like Nd-Fe-B [in practice this relates to coercivity], with a material such as pure Fe, which has a high saturation magnetization [and in practice affects the magnet's strength]. This concept could, in theory, lead to materials with energy products that are double or more of those presently available. While industrial-scale magnet materials of this kind are quite some way off, it was encouraging that a number of papers were presented on this area. George Hadjipanayis' group at the University of Delaware is particularly involved in this area of research, benefiting from a multi-year, multi-million dollar grant from the Defense Advanced Research Projects Agency to engage in research on these so-called meta-materials.

There were plenty of other interesting papers and posters not mentioned here, and they can be found in the published Proceedings of the meeting. The table of contents is a little confusing, with the inclusion of paper titles that are not included in the publication [the layout is based on session contents], and at least one paper was published twice in the book. In addition, some of the papers that were presented in the last session of the Workshop are not present in the Proceedings. This is presumably because the last session was held jointly with the opening session of NATO ARW meeting on bonded magnets. Nevertheless, the Proceedings stand as the best snapshot of the state-of-the-art of rare earth magnets research and development currently available.

The Workshop was not all work and no play. Almost everyone actively participated in a Greek Night that featured Greek dancing and music, dance and song from many attendees at the meeting, and a Crab Feast out in the countryside. The highlight of the week was the Banquet held at the Hotel du Pont in Wilmington. Dr. Chad Graham delivered the Karl Strnat Memorial Lecture, which gave a fascinating insight into the early years of rare earth materials development, and Karl Strnat's pivotal role in the discovery and production of Sm-Co alloys. Unfortunately, the Lecture was not published in the Proceedings as in previous years.

In addition, the Workshop Committee presented awards to a number of past and present members of the rare earth magnets community, for their distinguished contributions to the discipline. This list included Fred Jones, Hans Stadelmeier, Helmut Kronmüller, Mark Benz, Marlin Walmer, Norman Koon, and S Takeshida. Awards were also made to students who participated in an essay competition that was devised by the Committee – the winners were Maria Daniil, Kathleen Gallagher, Lorenzo Castaldi and Jian Zhou. Finally, executives from the International Magnetics Association [IMA], formerly known as the Magnetic Materials Producers Association, announced the winner of the IMA Scholarship Program for 2002, with the award going to Maria Daniil. The next meeting will be held in the south of France in 2004.



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