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Dayton is Not Just the Birthplace of Aviation, It's Also the Discovery Site of Modern Magnets

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Contact: Erika Mattingly
mattingly@udayton.edu

**DAYTON IS NOT JUST THE BIRTHPLACE OF AVIATION,
IT'S ALSO THE DISCOVERY SITE OF MODERN MAGNETS**

DAYTON, Ohio — To scientist Sam Liu, Dayton has always been synonymous with two milestones — the Wright Brothers' innovation of flight and the discovery of rare earth magnets.

One gets tons of attention; the other is a little-known fact.

Thanks to Liu's work as a principal investigator at the University of Dayton Research Institute, Dayton is still a center of magnet research. Under grants from the Department of Defense and Department of Energy, Liu and Ed Kuhl, a senior research physicist, along with three students and a part-time technician, are working to create high-temperature rare earth magnets for highly sophisticated Air Force jets.

Liu, fascinated by magnets at an early age, received a sponsorship from the Chinese government in 1980 to be a visiting scholar at the University of Dayton. At UD he studied with Karl Strnat and Alden Ray.

It was Strnat, assisted by Ray, who discovered the first generation of rare earth permanent magnets in 1966 while working at the materials laboratory at Wright Patterson Air Force Base.

Permanent magnets, such as common refrigerator magnets, are compounds that have constant magnetic properties. By combining elements such as samarium and cobalt from the rare earth section on the periodic table, Strnat and Ray discovered compounds that produced more energy than any other permanent magnet — rare earth permanent magnets.

Because of their research, permanent magnets have been discovered that are now used in everyday objects from the telephone to stereo speakers.

In 1968, Strnat joined Ray, a senior research metallurgist, and Herb Mildrum, a research engineer, at UD where they built a magnetics lab in UD's electrical engineering department.

In the 1970s, Strnat, Ray and Mildrum carried out research on the original samarium-

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cobalt compound that resulted in a second generation of rare earth magnets — capable of keeping their magnetic properties at temperatures as high as 300 degrees Celsius. Because the elements are scarce, the compound is expensive and is used mostly in military applications, such as controlling satellites and running motors.

However, the discovery prompted new research in the field.

In 1983, Japanese and then U.S. scientists announced a less-expensive Nd-Fe-B magnetic compound (neodymium-iron-boron) with an even higher energy capacity. This third generation of rare earth permanent magnets, made with less-scarce elements, can be found in telephones, computer disk drives, stereo speakers and medical MRI units.

Liu returned to UD in 1986 after spending four years teaching in China. He earned a doctorate and was hired by UD's Research Institute as a research materials engineer to continue where the UD researchers had left off — searching for improvements in the second-generation samarium and cobalt compound, which was generally ignored after the Nd-Fe-B compound was announced.

The Nd-Fe-B compound "has a high performance only at room temperature," according to Liu. So his five-member research team in UDRI's Kettering Laboratories focuses on the second-generation magnetic compound model while making variations by adding other elements.

Each new compound takes several days to test. The elements are melted in a vacuum, and the alloy is cooled, crushed and milled into fine particles. The particles are compacted and heat treated for a few days before being tested in a vibrating sample magnetometer that has a furnace attached.

High-temperature magnetic materials capable of operating at 450 C or higher are needed for advanced applications. After one year of research, Liu and his staff increased the compound's maximum temperature from 300 C to 400 C.

"We are getting pretty close to 450 C," Liu said, noting that each small improvement is celebrated by his staff. UDRI holds the world record for the samarium-cobalt magnetic compound with the highest energy product.

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For media interviews, call **Sam Liu** at (937) 229-3527 or e-mail sliu@engr.udayton.edu. For more information, contact **Erika Mattingly** at (937) 229-3212 or mattingly@udayton.edu.