

MPS/CAS Partner Group on Nanostructured Materials



Left: Professor Lu Ke (middle) with his group members and students in his laboratory. Right: Professor Manfred Rühle (left) and Professor John H. Perepezko (right) at the Scientific Advisory Board meeting for the Partner Group held in Shenyang.

Shenyang-Stuttgart

As one of the first Partner Groups which were initiated to foster scientific exchange and interaction between the Max Planck Society (MPS) and the Chinese Academy of Sciences (CAS), the Partner Group led by Lu Ke was established on April 1, 1999. During the past five years, the group has received substantial support from the CAS for equipment and from the MPS for personnel and travel expenses. Extensive and productive collaborations between the research staff and students of the Partner Group with several professors (departments) in the Max Planck Institute for Metals Research (MPI-MF) have led to significant advances in synthesis, mechanical properties, melting and superheating of nanostructured metals. The research is well recognized internationally and a substantial number of publications (including *Science* and *Physical Review Letters*) have resulted.

At the MPI-MF, Ke Lu has collaborated with Manfred Rühle and Reinhard Lück on crystallization studies, with Eric J. Mittemeijer on thermal stability and nanocrystal development, with Edward Arzt and Peter Gumbsch on computer simulation studies of melting and most recently with Huajian Gao and Helmut Dosch.

Reported by Group Leader Lu Ke

Major Research Themes of the Collaboration

1. Mechanical properties of nanocrystalline metals

It is useful to note that the development of twin microstructures is new and original at the CAS Institute of Metal Research. This work, which is considered to be outstanding, was mainly funded through the support of the Partner Group. The impact of this support of the research activities of Lu Ke through the Partner Group was enormous, especially in light of the very limited amount of funds. The most important aspect was that Lu Ke was able to send several students and postdocs to the different departments of the MPI-MF, where they were exposed to an international environment.

Selected publications

- Lu, L; Sui, M. L.; Lu, K (2000)
Superplastic extensibility of nanocrystalline copper at room temperature
SCIENCE, 287 (5457): 1463 – 1466
- Lu, L; Li, S. X.; Lu, K (2001)
An abnormal strain rate effect on tensile behavior in nanocrystalline copper
SCRIPTA MATERIALIA, 45 (10): 1163 – 1169

2. Surface treatment

The SMAT (Surface Mechanical Attrition Treatment) process to form nanostructures at materials surface is a new process developed by Lu Ke and his collaborators. Although

similar technologies such as shot peening exist, there are fundamental differences between shot peening and SMAT in terms of the objective and the processing principle. More importantly, this new technique has found increasingly interesting applications that result in substantial improvement of traditional material processing technologies. For example, by means of SMAT, the surface nitriding temperature of iron was considerably reduced from 550 °C to about 300 °C. This work, published in *Science*, demonstrated the technological significance of this development not only in improving traditional processing techniques, but also in providing new approaches for selective surface reactions.

Selected publications

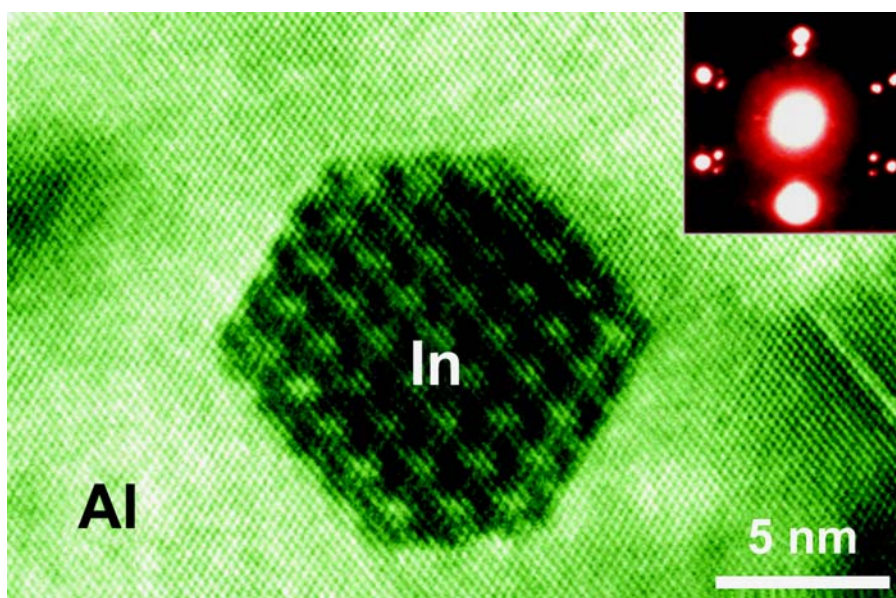
- Tong, W. P.; Tao, NR; Wang, Z. B.; Lu, J; Lu, K (2003)
Nitriding iron at lower temperatures
SCIENCE, 299 (5607): 686 – 688
- Tao, NR; Wang, Z. B.; Tong, W. P.; Sui, M. L.; Lu, J; Lu, K (2002)
An investigation of surface nanocrystallization mechanism in Fe induced by surface mechanical attrition treatment
ACTA MATERIALIA, 50 (18): 4603 – 4616

3. Pre-melting and superheating:

This work is excellent and is now being done in collaboration with Helmut Dosch's group.

Selected publications

- Jin, Z. H.; Gumbsch, P; Lu, K; Ma, E (2001)



High resolution transmission electron micrograph and electron diffraction pattern (inset) of an indium nanoparticle embedded in aluminum matrix with semi-coherent In/Al interfaces.

Melting mechanisms at the limit of superheating

PHYSICAL REVIEW LETTERS, 87, 055703

2. Zhang, L.; Jin, Z. H.; Zhang, L. H.; Sui, ML; Lu, K (2000)

Superheating of confined Pb thin films

PHYSICAL REVIEW LETTERS, 85 (7): 1484 – 1487

Potential Research Themes for Future Cooperation

1. Mechanical properties of nanostructured metals: experiments and computer simulations

Investigation of mechanical properties of nanostructured metals is currently one of the central topics in the field of materials science and has also been a key theme of the Partner Group in the past. The objective is to identify the intrinsic plastic deformation mechanism and to discover novel mechanical behavior in polycrystalline metals with grain sizes in the nanometer regime, which may have significant technological applications in modern industries. The study may include an experimental part (sample preparation and treatment, structure characterization, mechanical property tests, *etc.*) and a computer simulation part (on deformation mechanism in the atomistic scale). Various factors influencing mechanical properties will be systematically studied in nanostructured metals, such as grain size, grain boundaries, twin boundaries, stacking faults, *etc.*

Info

MPS/CAS Partner Group on Nanostructured Materials

Founding Date April 1999

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Edward Arzt and Huajian Gao in MPI-MF are expected to be collaborators on this project.

2. Phase transformation of low dimensional materials

Phase transformations, including melting, will be studied in low dimensional materials such as nanoparticles and thin films. The objective is to understand the kinetics and mechanism of several important phase transformations in materials, especially the nucleation and growth behaviors in the nanometer scale. Experimental investigations on the dimension effect, as well as the surface/interface effect on the phase transformation process, will be emphasized by using various advanced analyses techniques.

Helmut Dosch in MPI-MF is expected to be a collaborator on this project.