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Pressure-Induced Microstructural Changes of Au and Pt Nanomaterials at High Pressure

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The microstructure of nanoparticles, which is closely related to their size-tailored mechanical properties, has driven intensive investigations in the past decades [1-5]. It is recognized that the mechanical properties of nanoparticles may differ significantly from those of their bulk counterparts [2,3]. However, despite extensive studies, the origin of different mechanical behaviours as a function of their particle size remains elusive due to inconsistent results. Even for the well-studied gold, the equation of state (EOS) varies considerably (Fig. 1a). Both gold and platinum are common pressure markers in high-pressure experiments due to their low strength, moderate compressibility, chemical inertness, and good X-ray scattering power, and therefore have been thoroughly studied theoretically and experimentally, e.g. Refs [6-10]. Accurate EOS of Au and Pt is also very important for ultrahigh-pressure experiments in the mutli-megabar region.
In this conference, we report our recent progress in high-energy x-ray focusing[11] and the pressure-induced microstructural changes of nanocrystalline Au and Pt particles at high pressure by X-ray total scattering techniques(Fig. 1b) under quasi-hydrostatic conditions [11,12]. It is shown that the microstructure of n-Au is nearly a single-grain/domain at ambient conditions, but undergoes substantial pressure-induced reduction in grain size (Fig. 1c). The results indicate that the nature of the internal microstructure in n-Au is associated with the observed EOS difference from bulk Au at high pressure [12]. The internal microstructure inside nanoparticle plays a critical role for the macro-mechanical properties of n-Au and n-Pt particles.

Figure 1. (a) EOS of n-Au compared to previously reported data; (b) (Upper panel) Pair distribution function, g(r); (c) (Lower panel) Evolution of the average size of the Au nanodomains.
References:
[1] Q. F. Gu, G. Krauss, W. Steurer, F. Gramm, and A. Cervellino, Physical Review Letters 100, 045502 (2008).
[2] B. Gilbert, F. Huang, H. Zhang, G. A. Waychunas, and J. F. Banfield, Science 305, 651 (2004).
[3] S. H. Tolbert and A. P. Alivisatos, Science 265, 373 (1994).
[4] T. S. Duffy, G. Shen, J. Shu, H.-K. Mao, R. J. Hemley, and A. K. Singh, Journal of Applied Physics 86, 6729 (1999).
[5] B. Chen, K. Lutker, J. Lei, J. Yan, S. Yang, and H.-k. Mao, Proceedings of the National Academy of Sciences 111, 3350 (2014).
[6] T. Tsuchiya, Journal of Geophysical Research: Solid Earth 108, 2462 (2003).
[7] P. Souvatzis, A. Delin, and O. Eriksson, Physical Review B 73, 054110 (2006).
[8] Y. Fei, A. Ricolleau, M. Frank, K. Mibe, G. Shen, and V. Prakapenka, Proceedings of the National Academy of Sciences 104, 9182 (2007).
[9] K. Takemura and A. Dewaele, Physical Review B 78, 104119 (2008).
[10] S. M. Dorfman, V. B. Prakapenka, Y. Meng, and T. S. Duffy, Journal of Geophysical Research: Solid Earth 117, B08210 (2012).
[11] X. Hong, L. Ehm, Z. Zhong, S. Ghose, T. S. Duffy, and D. J. Weidner, Scientific Reports 6, 21434 (2016).
[12] X. Hong, T. S. Duffy, L. Ehm, and D. J. Weidner, Journal of Physics: Condensed Matter 27, 485303 (2015).
0102030405054565860626466687010203040051015020406001002003 00m-HEX diff. PDF (run-1) PDF (run-2) Vinet fit Bulk-Au (Dorfman et al) 30 nm Au (Gu et al) 50-100 nm Au (Martin et al)Volume (Å3)Pressure (GPa)EOS of Au(a)(b)G(r)r (Å)Pressure (GPa)Quenched7139202 run-1 run-2 EOS Pressure (GPa)QuenchedApparent size (Å)(c)

I plan to submit also conference proceedings

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