Ultra-high temperature Mo-Si-B alloys with melting points on the order of 2000°C are of great interest for high-temperature fossil energy applications. These alloys consist typically of Mo_3Si, Mo_5SiB_2, and a molybdenum solid solution phase. The Mo_5SiB_2 phase is required for oxidation resistance. The ductile molybdenum solid solution phase provides toughening. However, since its ductility is marginal, ways have to be found to improve it. In the 1960s, Scruggs found that powder-metallurgical Cr is ductilized by addition of MgO particles that transform into $MgCr_2O_4$ spinel particles [1]. Under the Fossil Energy Materials Program, M. P. Brady verified this ductilizing effect [2]. He determined that segregation of detrimental impurities such as nitrogen to the particle-matrix interface is one of the factors responsible for ductilization. Scruggs found also that Mo may be ductilized by adding $MgAl_2O_4$ or $NiAl_2O_4$ spinel particles [3]. To verify this effect, nominally pure Mo powder (2-8 μm) and spinel powder ($MgAl_2O_4$, 1-5 μm) were blended and Mo and Mo-3.4 wt% $MgAl_2O_4$ coupons were prepared by hot-pressing at 1800°C. Bend bars with a cross-section of 3x4 mm were polished and deformed at room temperature in three-point bending with a crosshead speed of 0.6 mm/min. As shown in Fig. 1, the Mo-3.4 wt% $MgAl_2O_4$ specimen was much more ductile than the pure Mo. If Mo-Si-B intermetallics with an α-Mo phase containing spinel particles could be produced, their fracture toughness would be substantially increased due to the increased ductility of the α-Mo phase. Read more about this work.

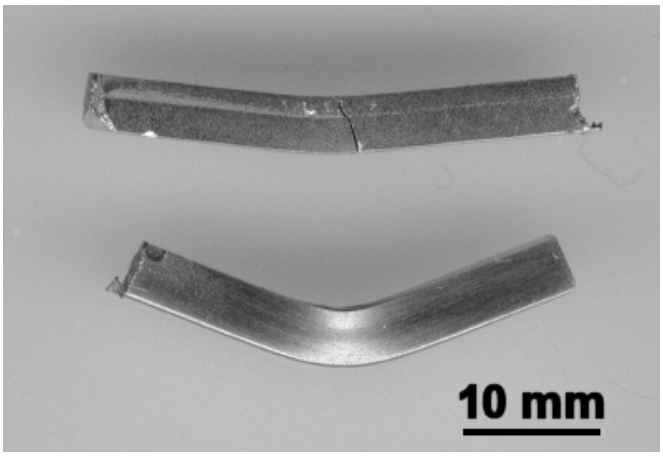

Figure 1. Comparison of the bend ductility of Mo (top) and Mo-3.4 wt% $MgAl_2O_4$ (bottom)

[1] D. M. Scruggs, L. H. Van Vlack, and W. M. Spurgeon, *J. Amer. Ceram. Soc.* **51** (1968) 473.

[2] M. P. Brady, I. M. Anderson, M. L. Weaver, H. M. Meyer, L. R. Walker, M. K. Miller, D. J. Larson, I. G. Wright, V. K. Sikka, a. Rar, G. M. Pharr, J. R. Keiser, and C. A. Walls, "Nitrogen impurity gettering in oxide dispersion ductilized chromium," accepted for publication in *Materials Science and Engineering A*.

[3] D. M. Scruggs, "Ductile tungsten composition containing a spinel dispersed uniformly throughout," United States Patent 3,320,037, Patented May 16, 1967.