A Critical Link between Amorphous Structure and Quasicrystal Formation

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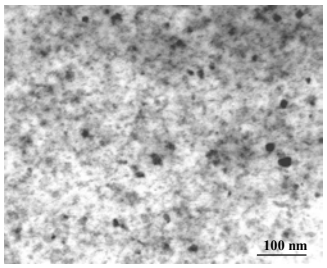
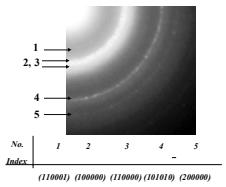
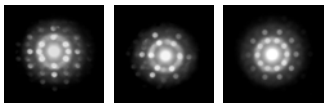
Motivation: Icosahedral quasicrystal (i-phase) formation upon crystallization of amorphous Zr-based alloys depends on how the alloys were initially amorphized, i.e. by melt spinning or mechanical milling. It has been assumed that medium range order (MRO) is predominant in the melt-spun alloys, which promotes the i-phase formation. However, the direct link between MRO and i-phase formation was not experimentally established. We extensively investigated MRO in melt-spun and mechanically-milled $Zr_{70}Pd_{30}$ and $Zr_{70}Pd_{20}Cu_{10}$ under both as-prepared and annealed conditions using Fluctuation Electron Microscopy (FEM). Our results show clearly that the preexisting MRO in melt-spun alloys is responsible for the formation of i-phase.

i-phase

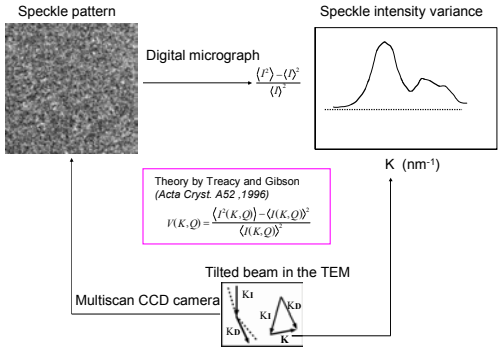




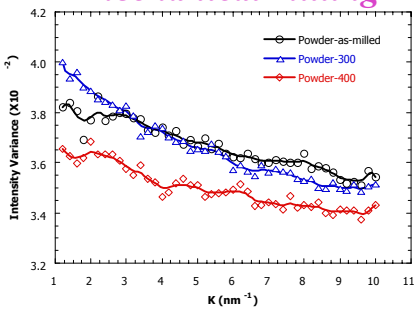


Precipitation of i-phase after annealing. Nanobeam electron diffraction showing 2-fold, 3-fold and 5-fold symmetries.

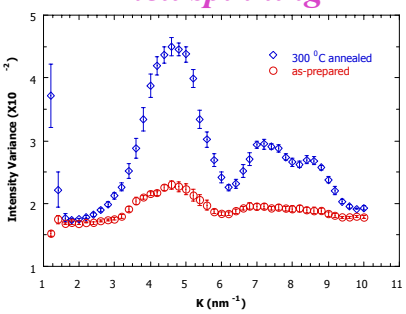
FEM for studying MRO



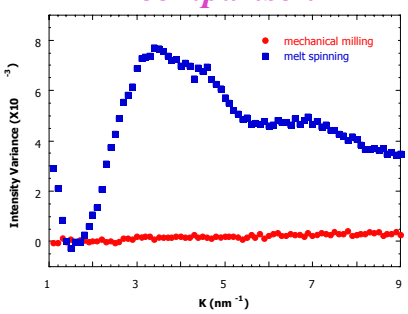
mechanical milling



melt spinning



comparison



Future work: In order to develop a more detailed and quantitative understanding, future research will be focused on (1) measurement of MRO length scale by variable resolution FEM, the variable resolution is achieved through a virtual objective aperture in STEM; (2) diffractive imaging of MRO; (3) modification of amorphous structure (disruption of MRO) by ion bombardment and its effect on the formation of i-phase; (4) FEM investigation into the influence of the preparation conditions such as quenching rate and alloying composition on MRO and i-phase.

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