ESRF	**How perfect are "highly perfect" quasicrystals?**	**Experiment number**: HS-2088
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Shifts: 6	**Local contact(s)**:J. Härtwig	*Received at ESRF:*

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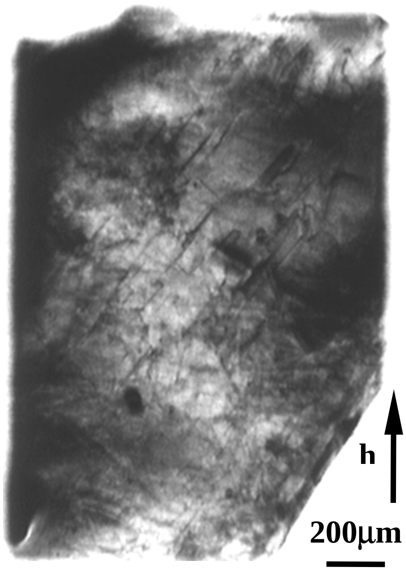
Report:

In the recent years researchers have obtained quasicrystals, solids that present long-range atomic order but no periodicity, of rather high quality showing rocking curve widths comparable to those of the best metallic crystals. However, they still contain a considerable amount of defects, which are the subject of intense studies. This is because defects may have a great impact on the physical properties, and because their formation, their properties, their exact strain fields and their transformation are far from being fully understood.

Icosahedral Al-Pd-Mn, produced by slow solidification techniques, is probably the quasicrystalline alloy with the highest structural perfection obtained up to now. Few of best grains show diffraction effects, which have been explained in the frame of the dynamical diffraction theory, like anomalous transmission [1-7]. However, they still contain a considerable amount of defects, which are the subject of intense studies [6, 8]. Our intention was to further investigate of such a "highly perfect" quasicrystalline grain applying different characterisation methods having spatial resolution on different scales (sub microscopic, microscopic resolution) and being local and integral methods. These were X-ray diffraction topography (local measurement of perfection, strain fields related to pores, dislocations, …), phase-sensitive X-ray radiography (with phase reconstruction, to visualize pores), high-resolution X-ray diffraction (integral measurement of perfection, phason strain), and transmission electron microscopy. The selected grain was located in an icosahedral Al-Mn-Pd polyquasicrystalline slice. We should mention, that these samples, and all the others investigated in [1-7] stem from the same ingot and were made available by S. Kycia. It was Bridgman grown, has the composition $Al_{71.0}Pd_{20.5}Mn_{8.5}$, was Diamond polished, not annealed, and has a thickness of t = 0.385 mm.

The experimental results lead to the following conclusions:

- The investigated "highly perfect" grain with an extremely narrow rocking curve contains still a lot of defects and is strongly strained (Figs. 1, 2).
- The dislocation density seems to be so low that individual dislocations may be resolved by X-ray topography and anymore by TEM (Fig. 1).
- This "highly perfect" icosahedral Al-Pd-Mn quasicrystal grain seems to contain defects like inclusions (Fig. 3). No pores could be found with this technique within the detection limit (larger than about 0.5µm).



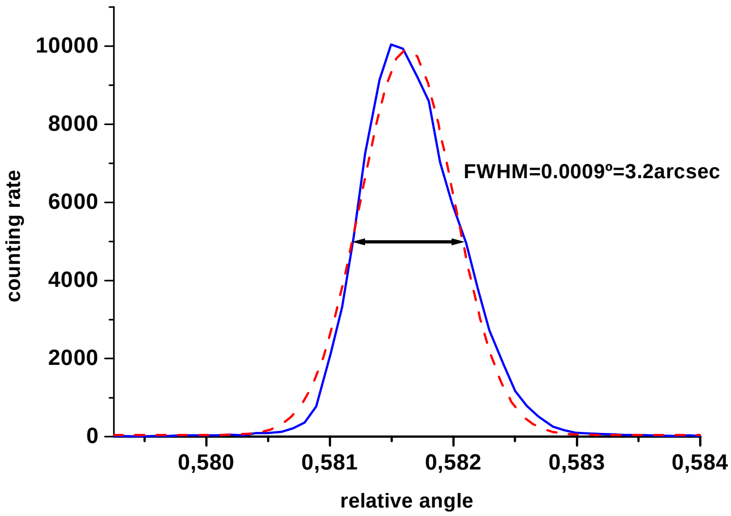


Fig. 1: Reflection τ^3(0/2 0/0 0/0), 2-fold axis, rocking angle 0.025°, sample-to-film distance $d_{s\text{-}f}$ = 4cm, beam energy 24keV. **h** - diffraction vector.
Contrasts due to global bending, dislocations, pores and two-dimensional defects visible.

Fig. 2: Measured rocking curve (straight line) in a 50*50 μm^2 field, reflection (0/2 0/0 0/0), together with a Gaussian fit (dotted line), full width at half maximum (FWHM) is about 0.0009degrees

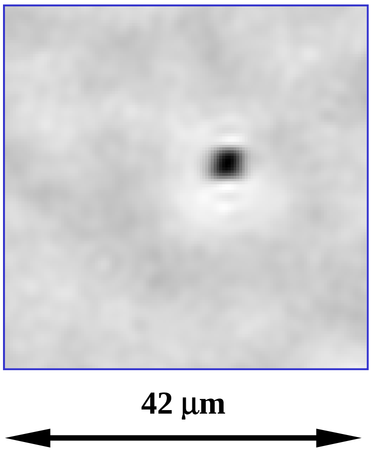


Fig. 3: Phase images showing probably an “inclusion”. Pixel size 0.33µm, beam energy 24keV, reconstructed from 4 images at distances 12, 20, 45, 100mm

The dark object has a diameter of about 3µm and a density about 0.5gcm^{-3} larger as the matrix,
No pores could be found with this technique!
Pores are smaller than the detection limit of about 0.5µm

References

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