Challenging Materials for Challenging Applications

Texture of metals is linked to specific physical properties, so the need to characterize it at nanometer scale


synthetic sapphire

Synthetic Sapphire is a single crystal form of corundum, Al_2O_3, also known as alpha-alumina, alumina, and single crystal Al_2O_3. Synthetic sapphire is the hardest of all known oxide crystals with a 9 on the Mohs scale.It is second in hardness only to diamond, and retains its strength at high temperatures. Synthetic sapphire crystals have good thermal properties, with excellent electrical and dielectric properties. In addition, it combines zero porosity with near total resistance to acids and alkaline substances. In its purest form, no porosity or grain boundaries are present, making it theoretically dense. The combination of favourable chemical, electrical, mechanical, optical, surface, thermal, and durability properties make sapphire a preferred material for high performance systems and component designs. Due to these benefits sapphire has been used in various applications, such as sapphire wafers, lenses, substrates, watch glasses, and sapphire boule for many years. Synthetic sapphire is anisotropic hexagonal crystal. Its properties depend on crystallographic direction (relative to the optical C-axis).For various semiconductor applications, sapphire is the best choice in comparison to other synthetic single-crystals.


luxury watch

The challenge:	Being able to identify correctly orientations in Al_2O_3 to study defects
Solution:	ASTAR technique coupled with precession electron diffraction

Sapphire is widely used for watch glasses. The world demand in the watch industry centres on scratchproof sapphire watch crystals. However, besides traditional flat shapes, crystals with spherical and cylindrical curves are also in great demand.

Did you know? Sapphire is the substrate for the growth of III-V and II-VI compounds such as GaN for LED's, used for LED.


Hip replacements

Another important application is the realization of hip prothesis, because of the biocompatibility and inert behaviour of sapphire in human bodies, combined with exceptional mechanical properties!

Thus, Analysis of polycrystalline sapphire, to understand the structure of defects and grain boundaries, was essential and was performed in high resolution using the ASTAR in combination with preccesion electron diffraction technique.


LED light

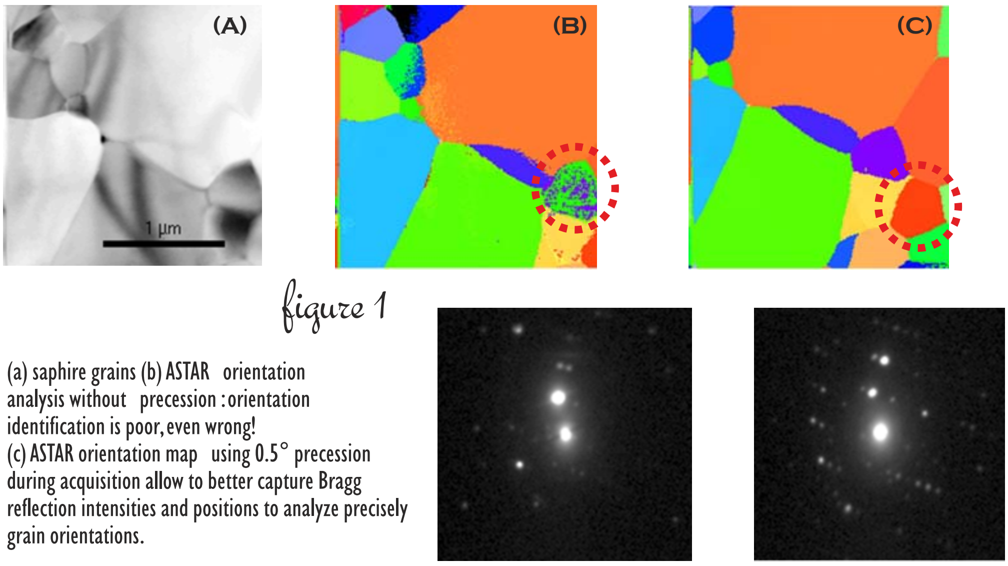

figure 1

(a) saphire grains (b) ASTAR orientation analysis without precession : orientation identification is poor, even wrong!
(c) ASTAR orientation map using 0.5° precession during acquisition allow to better capture Bragg reflection intensities and positions to analyze precisely grain orientations.

Crystal Structure

Al_2O_3: Trigonal, $R\bar{3}c$
a = 4.78 Å, c = 12.99 Å

Experimental Data

TEM type: Tecnai F20
Map resolution: 1 nm
Scanned area: 2 x 2 µm

Courtesy Dr. A. Gholinia , Manchester University UK
K. Spencer, M. Veron et al *Materials Science and Engineering A* 387-389 (2004)