TEM investigations of a friction film on a brake disc

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Automotive brake systems must provide a stable friction level under extreme conditions. A good performance depends on friction layers, which develop during the so-called run-in process and is important for a stable COF (Coefficient Of Friction). While the discs usually are made of grey cast iron, the pad formulations are more complicated. Friction materials like Polymer matrix composites (PMC) are based on phenolic resin with a large number of constituents which fulfill certain functions.

The friction films comprising of a nanocrystalline structure of pad constituents and iron oxide provide stable friction conditions and a friction level which is needed for braking.

Studies based on modelling with a method of movable cellular automata (MCA) and an automata size of 10 nm had shown that the films should contain at least 10 vol % of a solid lubricant to guarantee smooth sliding irrespective of the applied pressure [1].

In this contribution we present results of the nanostructure of the friction films on the brake discs. For the TEM investigations we used a STEM JEM 2200FS (JEOL) equipped with an Omega filter and an EDX-detector.

The samples were prepared with two different methods. The first, our standard method, is the preparation of micro-cross-sections with the FIB and in-situ lift-out. The second preparation method comprised scratching of the disc surface with a diamond tip and collecting the film fragments at the edge of wear scar. This is suitable for very thin films on the disc.

Figure 1 shows a FIB cross-section of the disc with a thin friction film. In figure 2 a friction film consisting of compacted nanocrystalline iron oxide particles as matrix including graphite nanoparticles with a size of 5 to 10 nm is shown. Some coarser inclusions, presumably iron carbide, are visible as well. They may arise from fragmentation of the pearlitic structure of the cast iron, shown in figure 1. Further evidence for the described nanostructure was obtained by HRTEM showing lattice planes of magnetite, and by electron diffraction of plan-view film fragments showing ring patterns corresponding to magnetite and occasionally also a faint ring corresponding to (0002)-graphite planes.

The results corroborate the assumptions made for modeling of the sliding behavior of surface films. It has been shown that oxide films with hard and soft inclusions are essential for providing stable friction properties at the desired COF level [1].

1. W. Österle et al., SAE Brake Colloquium 2008 paper 2008-01-2582, pp. 303-311
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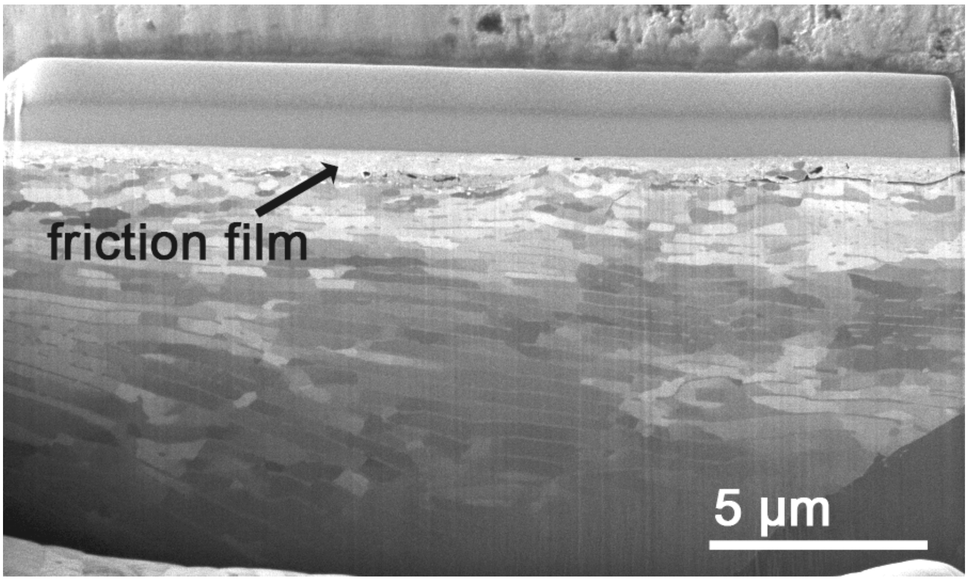

Figure 1. FIB-lamella prepared from a brake-disc with friction film.

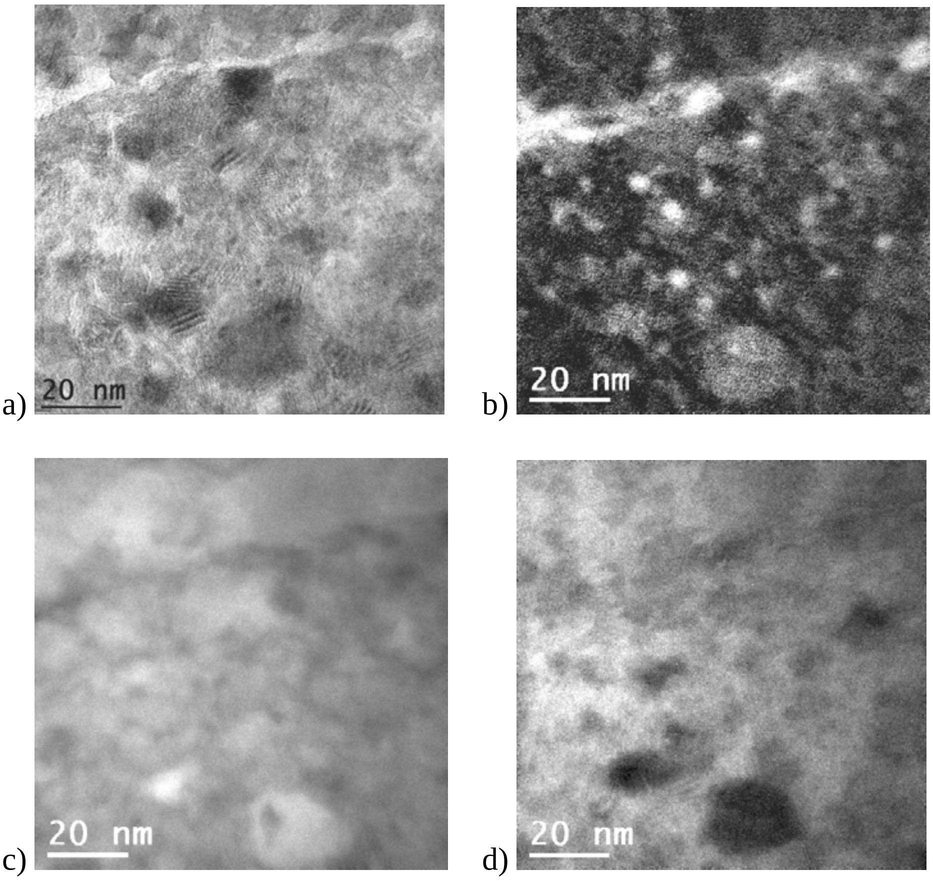

Figure 2. EFTEM elemental maps of the friction film. a) zero-loss image, b) carbon-map, c) iron-map and d) oxygen-map.

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