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Optical characterization of roughness on polished steel surfaces

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To fabricate nanostructured polymer devices by injection molding set strict demands on the smoothness of the mold master. Structuring a surface requires that the surface do not have roughness above the feature length scale, but preferably far below. For nanoscale structures this imposes a strict requirement, and demands careful polishing of the unstructured master steel inserts. Although surfaces of this quality definitely are obtainable with present industrial fabrication methods, they also need to be characterized and validated, preferable with an easy in-process method.

In this work, we compare three optical methods for characterizing nanoscale roughness: a laboratory scatterometer setup which measures the angle-resolved scattering (ARS) and bi-directional reflection distribution function (BRDF) of light scattered from a surface; a small industrial scatterometer called an OptoSurf, also measuring the ARS but only in a narrow range of ±16°; a confocal 3D optical profiler, which provide a 3D surface profile.

The roughness parameters evaluated are: the root-mean-square height (Rq), the root-mean-square slope (Rdq), both defined in the ISO 4287 standard, and the normalized variance of the scattered light distribution (Aq), defined in a German industry standard [1].

The OptoSurf fits into industrial production equipment, and has shown good results as quality control in the Nanoplast project [2]. Unfortunately it only measures the none-certified Aq value. In this work we present a relation between the OptoSurf Aq value and the more known Rq parameter. Based on the Aq value of the narrow range and the amount of light lost outside this range, the Aq value of the full range is determined, and further correlated with the Rq value. This enables a fast an easy characterization of surface roughness, with an industrial applicable tool.

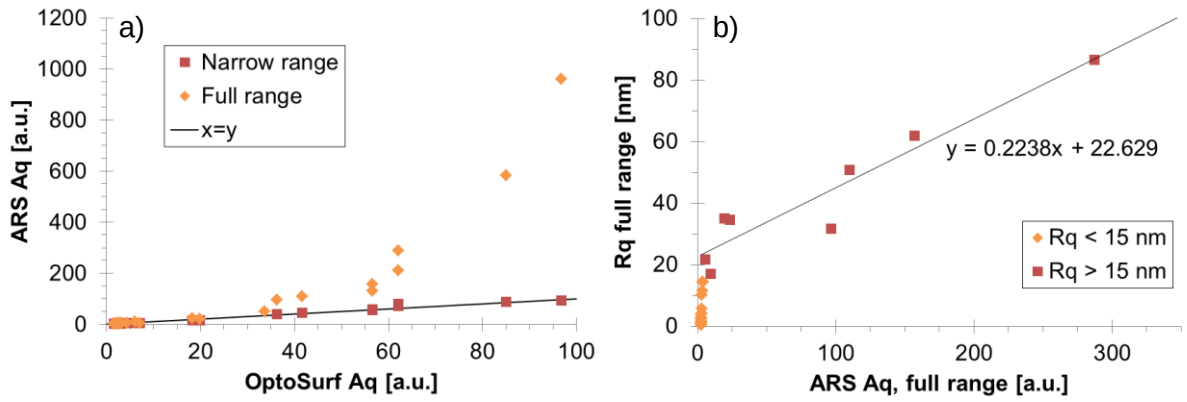

Figure 1: a) Comparison of Aq values reveal good agreement between the ARS and OptoSurf setup, when both are constricted to the narrow range of ±16°. The full range values (±90°) show a consistently increasing trend, enabling the prediction of these values. b) Relation between the full range Aq and Rq values, showing that the ISO standardized Rq value can be determined from the lesser known Aq value.

References

1: Verband der Automobilindustrie. VDA 2009:2010-07 - Angle-resolved light scattering measurement.
2: www.nanoplast.dk