Optimization of the optical readout of PEEK cantilevers

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INTRODUCTION: Using cantilever beam bending approach it is possible to determine the contractile forces of an ensemble of biological cells with nano-Newton resolution [1]. Si(100) wafers used as the cantilever material so far are rather expensive and difficult to handle because they are brittle. Owing to its biocompatibility 50 µm-thin polyetheretherketone (PEEK) is an interesting alternative to the silicon cantilevers.

Investigating the impact of substrate surface morphology on contractile cell forces we want to improve the surface of medical implants. Due to the limited reflectivity of PEEK, a reflecting layer such as a metallic film should be added. The aim of the study is the determination of the necessary gold thickness to obtain the required reflectance.

METHODS: A specially designed system was realized to measure the contractile cell forces of an ensemble of thousands cells. Light from a laser is reflected from the free end of the cantilever onto the position sensitive detector (PSD). As changes in cellular contraction or adhesion forces influence the curvature of the cantilever, the reflection angle and thus the final position of the laser beam on the PSD will change accordingly. This change in position is detectable allowing a quantification of the force using the Stoney formula [2]. We embossed the 50 µm-thick PEEK films on the rough side with plain pattern and 10 µm wide periodic pattern, using the hot embossing system HEX 03 (JENOPTIK Mikrotechnik GmbH, Jena, Germany). Through the thermal evaporator (BALZERS, Oerlikon, Switzerland) we coated the embossed PEEK films on the smooth side with a gold layer with thicknesses varying from 20 nm to 80 nm. First, we coated the polymer film with 4 nm chromium as sticky layer between PEEK substrate and gold film. The transmittance and reflectance of the embossed coated PEEK films are measured with the UV/VIS/NIR spectrometer Lambda 19 (Perkin Elmer, Massachusetts, USA).

RESULTS: The reflectance of the coated PEEK at the wavelength of 633 nm is of interest, because this is the wavelength of the laser used in the sensing system. As shown in Fig. 1, the reflectance increases with the gold coating thickness for both plain pressed and microstructured PEEK substrates according to the following relation:

$$R = 100\% - 55\%*\exp(-t/(28\pm2)\ \text{nm}).$$

The reflectance saturates for an infinite gold film and corresponds to 45%, if no gold film was deposited. The error bars of the reflectance and the gold thickness correspond to 2% and 2 nm, respectively.

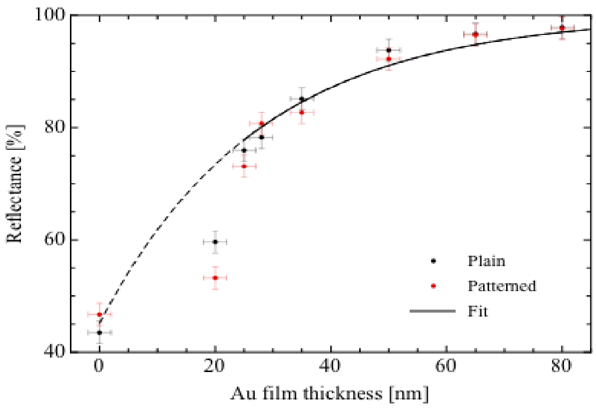

Fig. 1: Relation between reflectance and gold film thickness to determine an optimized film thickness for contractile cell force measurements.

DISCUSSION & CONCLUSIONS: There is no significant difference in reflectance between the plain and the patterned PEEK substrates. The curve progression only follows the added gold film thickness. Therefore, both data can be fitted simultaneously. The fit perfectly describes the data with one exception. For the 20 nm-thin gold film, the observed reflectance is well below the fitting curve. This behaviour can be explained by islanding, i.e. at 20 nm the gold film is not a confluent layer. Therefore, we conclude that a gold film with a thickness of 28 nm should be applied for experiments with PEEK substrates.

REFERENCES: [1]J. Köser, S. Gaiser, B. Müller (2011) *Eur Cells Mater* **21**:479-487. [2]G.G. Stoney (1909) Nature 172-175.

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