Electronic Supplementary Material (ESI) for RSC Advances.

Supplementary Information

1. AFM characterization of surface roughness

AFM characterizations were done to study the influence of experimental process on surface roughness. Fig SI-1 shows as an example of a PVP buffered Si/SiO2 substrate. The characteristic roughness values Ra (the arithmetic average of the absolute values of the surface height deviations measured from the mean plane) and Rq (the root mean square average of height deviations taken from the mean data plane) were determined to be 0.162nm and 0.205nm. The measured values are not significantly different from the values measured on the standard substrate Si/SiO2. After the substrates are deposited with 35 multilayers (ML) PyCu film, the surface roughness is increased. Table SI-1 contains Ra and Rq after main process steps. Data shows that there is no characteristic difference between PVP buffered and standard substrates.

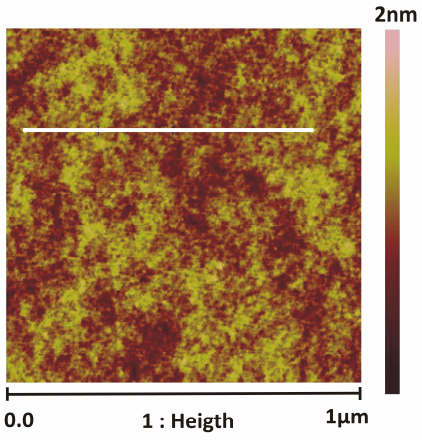

Fig SI-1a

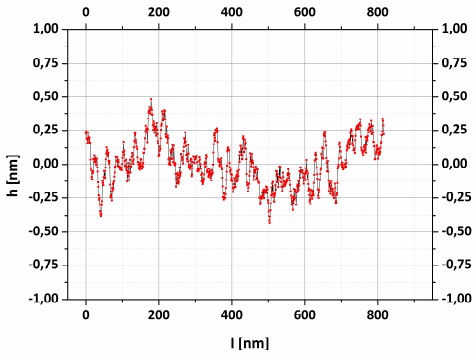

Fig SI-1b

Fig SI-1: AFM image (a) and the corresponding line-scan (b) of a PVP buffered Si/SiO2 substrate.

Table SI-1: Ra and Rq values of different surfaces measured by AFM

	Standard substrate		PVP buffered substrate	
	Si/SiO2	Si/SiO2+35ML PyCu	Si/SiO2 /PVP	Si/SiO2/PVP+35ML PyCu
Ra (nm)	0.172	0.378	0.162	0.368
Rq (nm)	0.209	0.481	0.205	0.475

2. Production of test containers

Ma-N 415 photoresist (Micro Resist Technology GmbH, Berlin, Germany) was mixed with iron-filled CNTs synthesized with our former technology and the fluorescent dye rhodamine (in ethanol), and then the mixture was transferred onto PDMS foils using polymer-printing technology. The negative resist was cured immediately after printing using UV radiation with a wavelength of λ=365nm for 60s. This allowed shape-retaining functionalized compartments to be created which could easily be removed from the PDMS carrier substrate and used in that form for the experiments. Thanks to their multifunctionalization, these containers could both be detected magnetically and counted in the fluorescence microscope.

3. Creating the channel structures

The techniques used to create the channel structures fully depend on the required geometry. To produce structures in the depth range of less than 2µm, conventional ion beam etching was used. For deeper structures, a wet chemical etching process was fine-tuned. It is known from the literature that PEEK cannot withstand H_2SO_4 [1] and thus the fluidic structures were produced by etching in H_2SO_4 at 80°C. Under this condition, it is however not possible to use conventional photoresist. To create a defined geometry, the PEEK foil was deposited with 100nm of Cr on both sides thermal evaporation with a deposition rate of 0.3nm/s. Photoresist was deposited

onto it and a patterning process was carried out using a conventional mask aligner. The areas not covered with photoresist were dissolved at room temperature using an etching solution based on $(NH_4)Ce(NO_3)_6$ 0.3mol/l + $HClO_4$ 0.5mol/l. The Cr was etched at a rate of about 1nm/s. After the photoresist was removed by Acetone, the substrate was treated in a H_2SO_4 solution at 80°C. The required time depends on the intended depth of the channels. The etching speed was around 1µm/min. The hard mask of Cr is sufficiently stable under the selected conditions and then is removed using a wet chemical process after the PEEK etching process has been carried out. The difference between the etching processes used is revealed particularly in the forming of the channel side walls. While the dry chemical process is anisotropic and the wet chemical process is isotropic, which result in the different angle between the base and the wall of the channel, the angle by IBE process tends towards 90° and angle by wet chemical etching process tends towards <45°. It is possible to combine the two etching methods to produce different channel depths on one substrate. An example of fabricated channel structure in PEEK by IBE is shown in Fig SI-2.

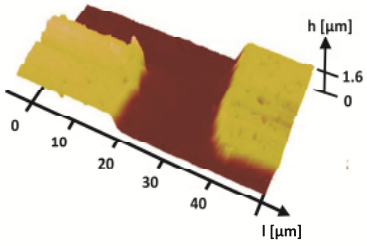

Fig SI-2: An example of fabricated channel structure in PEEK by IBE, the base area is very smooth and angle between the base and the wall of the channel is >60°.

4. Transfer the GMR layer

Once the channel structures had been created, the sensor structure was transferred onto the underside of the PEEK substrate. As mentioned in paper's "Developing the transfer process" section, our own experiments involved both transferring geometrically well-defined structures and transferring complete, extensive layers then structuring them on the receiver substrate. No differences were found in the level of the GMR effect depending on the type of process. To do so, our transfer process was used to transfer entire PyCu films measuring 50mm x 50mm. The donor substrate used was PVP-u buffered Kapton® foil. Once the PEEK substrate had been coated with epoxy resin (DELO-KATIOBOND® KB554) by spin-coating at speed of 2000 round/min, preactivated using light in a wavelength of λ = 460nm, the two substrates were joined mechanically with a force of 10N. This creates a bond between the two materials. Within 24h at room temperature, the final strength of adhesion is realized. After that, the composite is placed in water with a temperature of 25°C. The water dissolves the uncured PVP and the PyCu film no longer adheres to the donor substrate. The PyCu film was then structured into the desired pattern by conventional optical lithography and IBE. For better contacts, an additional contact material such as Al can be applied and patterned. When Al is used, interconnections to the measurement area can be created using ultrasonic wire bonding.

References:

1. Products Data Sheet PEEK (www.solidspot.com), 2014.