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Carbon nanotubes based ultrasonic transducer: realization process, morphological and mechanical properties

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For instrumentation of microporosity in cementitous materials, carbon nanotubes based capacitive ultrasonic transducers (cMUT) are promising sensors [1]. Their interest lies in the combination of high working frequencies (1 GHz) with small dimensions (1 µm²). In the proposed device, the cMUT membrane is made of aligned single-walled carbon nanotubes (SWNT) bridging a gap over a command electrode. We will describe the realization process of the vibrating membrane and its characterizations. \newline First step of the device realization is the dispersion of SWNTs in N-methylpyrrolidone. Then, nanotubes are aligned by dielectrophoresis (DEP) between metallic electrodes onto a SiO2 substrate. A metallic layer is deposited over the electrodes edges to prevent nanotubes from slipping when suspended. The underlying SiO2 is then etched to release the membrane. \newline Relevant features of the membrane are nanotubes alignment and density. Via SEM imaging, we have linked them with DEP operating parameters, in agreement with theoretical properties of DEP [2]. To put a figure on membrane features, we are working on SEM image processing for nanotubes recognition. The method is based on advanced noise removal and contrast enhancement. First results of identification and measurement of intermeshed nanotubes on SEM pictures will be presented. \newline We also mapped the Young's modulus of a suspended membrane using an AFM in contact mode, over surfaces of about 1 µm² surface. It opens the way for calculation of localized Young modulus, Poisson's ratio and thickness measurement of the membrane. We will check for correlations between mechanical data and quantitative properties of the deposition obtained from image processing. \newline The optimization of membrane realization process and characterization techniques are presented, describing the present progress of our cMUT project. Next step will be actuation of the membrane to demonstrate vibrations at low frequency.

1. Références

1. Lebental et al., In-situ non-destructive testing of cementitious materials with embedded ultrasonic transducers made up of carbon nanotubes, NDTCE'09, June 30th – July 3rd, 2009
2. M. Dimaki and P. Boggild, Dielectrophoresis of carbon nanotubes using microelectrodes: a numerical study, Nanotechnology 15 (2004) 1095-1102