Self-assembly of Si- and SiGe-based dielectric Mie resonators via templated solid-state dewetting

M. Naffouti[1], T. Wood[1], M. Salvalaglio[2], J. Berthelotc[3], T. David[1], J.-B. Claude[1], L. Métayer[1], L. Favre[1], A. Ronda[1], I. Berbezier[1], N. Bonod[3], R. Backofen[2], M. Lodari4, A. Voigt[2], M. Bollani[4], M. Abbarchi[1]

[1] CNRS, Aix-Marseille Univ., Centrale Marseille, IM2NP, UMR 7334, St. Jérôme, 13397 Marseille, France
[2] Institute for Scientific Computing, Technische Universität Dresden, Willers-Bau B–Zellescher Weg 12-14, Dresden D-01062, Germany
[3] Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, Marseille, France
[4] IFN-CNR, L-NESS, via Anzani 42, 22100 Como, Italy

e-mail: marco.abbarchi@im2np.fr

Abstract **– Dielectric Mie resonators have attracted a great deal of attention over the past few years thanks to their remarkable capabilities in manipulating light propagation at the nanoscale[1,2,3]. However, the practical implementation of technological products is still elusive. Important limits are the absence of a high-performing material and a fabrication method that can be easily integrated into modern micro-electronic devices at affordable costs. Here, we provide theoretical and experimental evidence of solid state dewetting of ultra-thin silicon and silicon-germanium films on insulators as an alternative fabrication method and semiconductor material for dielectric Mie resonator applications[4-7]. These dielectric resonant particles can be obtained over very large surfaces[4] on arbitrary silica substrates[5]. Remarkably, this self-assembly process is independent on the sample size. Furthermore, the Si(Ge) islands can be precisely organised in uniform arrays and complex oligomers arrangements[6] featuring low size dispersion. Their composition profile can be controlled *a posteriori* via a Ge condensation process to form core-shell Si/SiGe islands[7,8] and their diffusion spectrum can be electrically tuned by changing the refractive index of the environment. As an example, we demonstrate SiGe-based Mie resonator arrays functioning as colour pass-band filters across the full visible spectral range[9]. The filters function both in transmission and diffusion and are fabricated using a methodology compatible with C-MOS technology. We note that the use of SiGe-based alloys in novel electronic devices, such as FET and C-MOS transistors, is nowadays extremely important. Because of this, opening the field of dielectric MRs to SiGe-based semiconductor alloys is an important step forward towards the integration of photonics with electronic devices.**

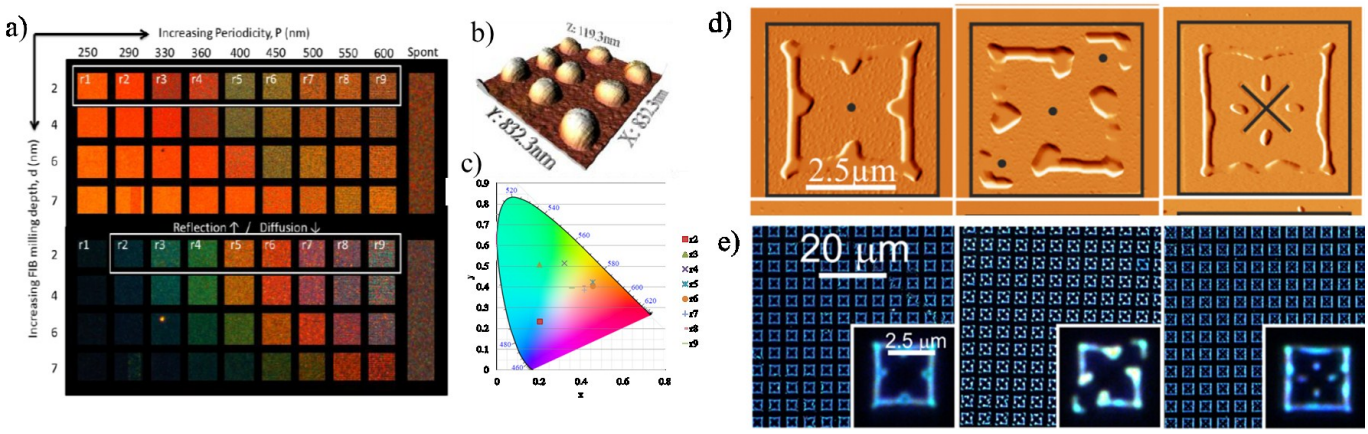

Fig.1. a) Top (bottom) panel: Bright (Dark)-field microscope images of reflection (diffusion) from SiGe-based Mie resonators obtained via solid state dewetting of 50 nm Si0.8Ge0.2. b) AFM image of pattern r8 of a). c) CIE chromaticity gamut of light diffusion from the patterns shown in a). d) AFM images of e-beam and RIE assisted solid state dewetting of patches etched on 12 nm Si on SiO2. d) Optical dark–field images of arrays of dewetted patches.

REFERENCES

[1] Jahani et al., Nat. Nano. **11**, 23 (2016)
[2] Decker et al., Journal of Optics, **18**, 1 (2016)
[3] Bottein, et al., Advanced Functional Materials, **27**, 1604924 (2016)
[4] Abbarchi, et al., ACS Nano, **8** 11181 (2014)
[5] Naffouti et al. Nanoscale **8**, 2844 (2016)
[6] Naffouti et al., Small **12**, 6114 (2016)
[7] Naffouti et al., Nanotechnology, **27**, 305602 (2016)
[8] David et al., The Journal of Physical Chemistry C **119**, 24606 (2015)
[9] Wood et al., ACS Photonics **4**, 873 (2017)