Characterization of ultraviolet light cured polydimethylsiloxane films for low-voltage, dielectric elastomer actuators

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Author(s) Topper, Tino; Wohlfender, Fabian; Weiss, Florian; Osmani, Bekim; Muller, Bert
Author(s) at UniBasel Osmani, Bekim ; Wohlfender, Fabian ; Töpper, Tino ; Weiss, Florian ; Müller, Bert ;
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The reduction the operation voltage has been the key challenge to realize of dielectric elastomer actuators (DEA) for many years - especially for the application fields of robotics, lens systems, haptics and future medical implants. Contrary to the approach of manipulating the dielectric properties of the electrically activated polymer (EAP), we intend to realize low-voltage operation by reducing the polymer thickness to the range of a few hundred nanometers. A study recently published presents molecular beam deposition to reliably grow nanometer-thick polydimethylsiloxane (PDMS) films. The curing of PDMS is realized using ultraviolet (UV) radiation with wavelengths from 180 to 400 nm radicalizing the functional side and end groups. The understanding of the mechanical properties of sub-micrometer-thin PDMS films is crucial to optimize DEAs actuation efficiency. The elastic modulus of UV-cured spin-coated films is measured by nanoindentation using an atomic force microscope (AFM) according to the Hertzian contact mechanics model. These investigations show a reduced elastic modulus with increased indentation depth. A model with a skin-like SiO2 surface with corresponding elastic modulus of (2.29 ś 0.31) MPa and a bulk modulus of cross-linked PDMS with corresponding elastic modulus of (87 ś 7) kPa is proposed. The surface morphology is observed with AFM and 3D laser microscopy. Wrinkled surface microstructures on UV-cured PDMS films occur for film thicknesses above (510 ś 30) nm with an UV-irradiation density of 7.2 10-4 J cm-2 nm-1 at a wavelength of 190 nm.
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