Raman spectroscopy for monitoring strain of silver nanowires on flexible substrate

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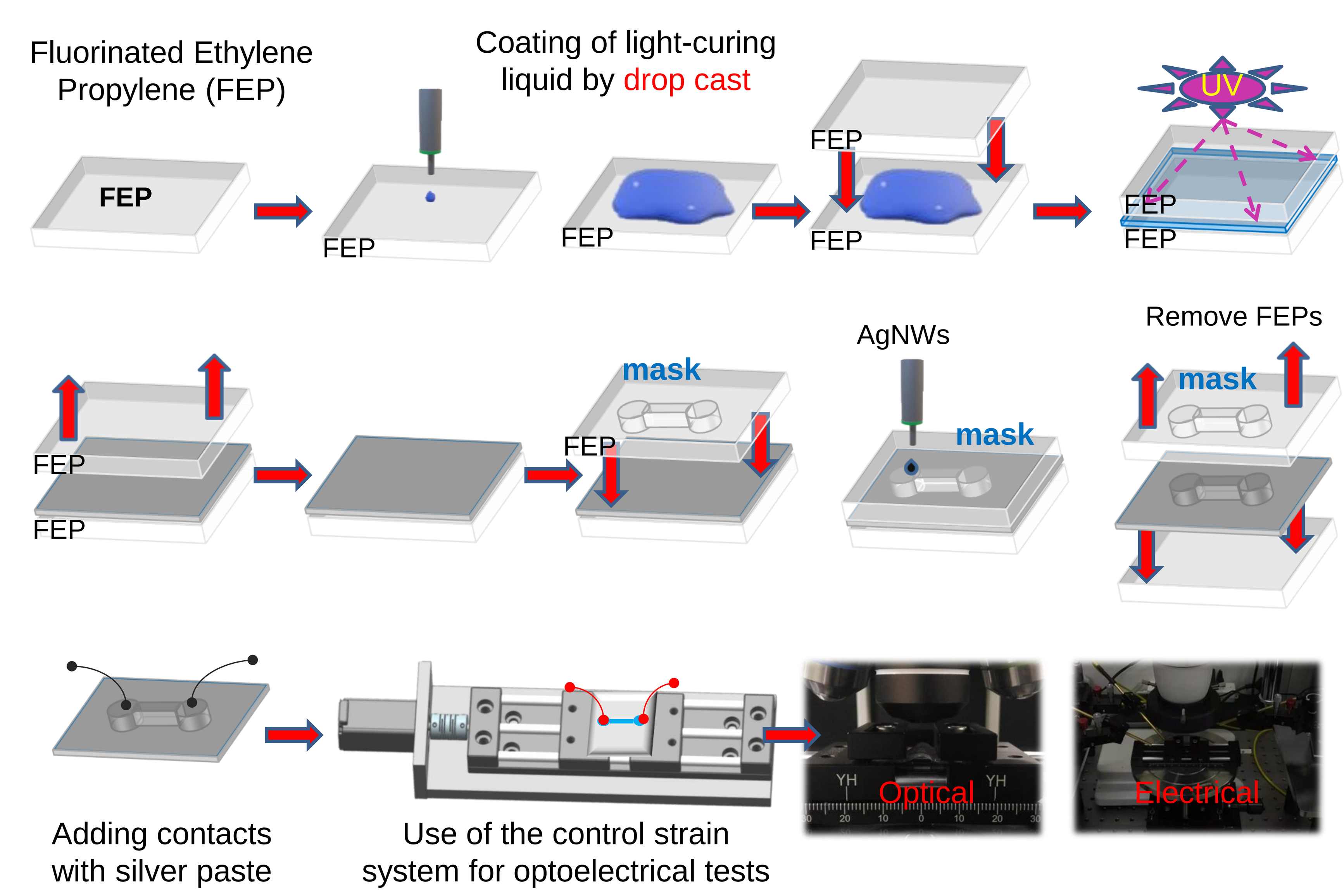
INTRODUCTION

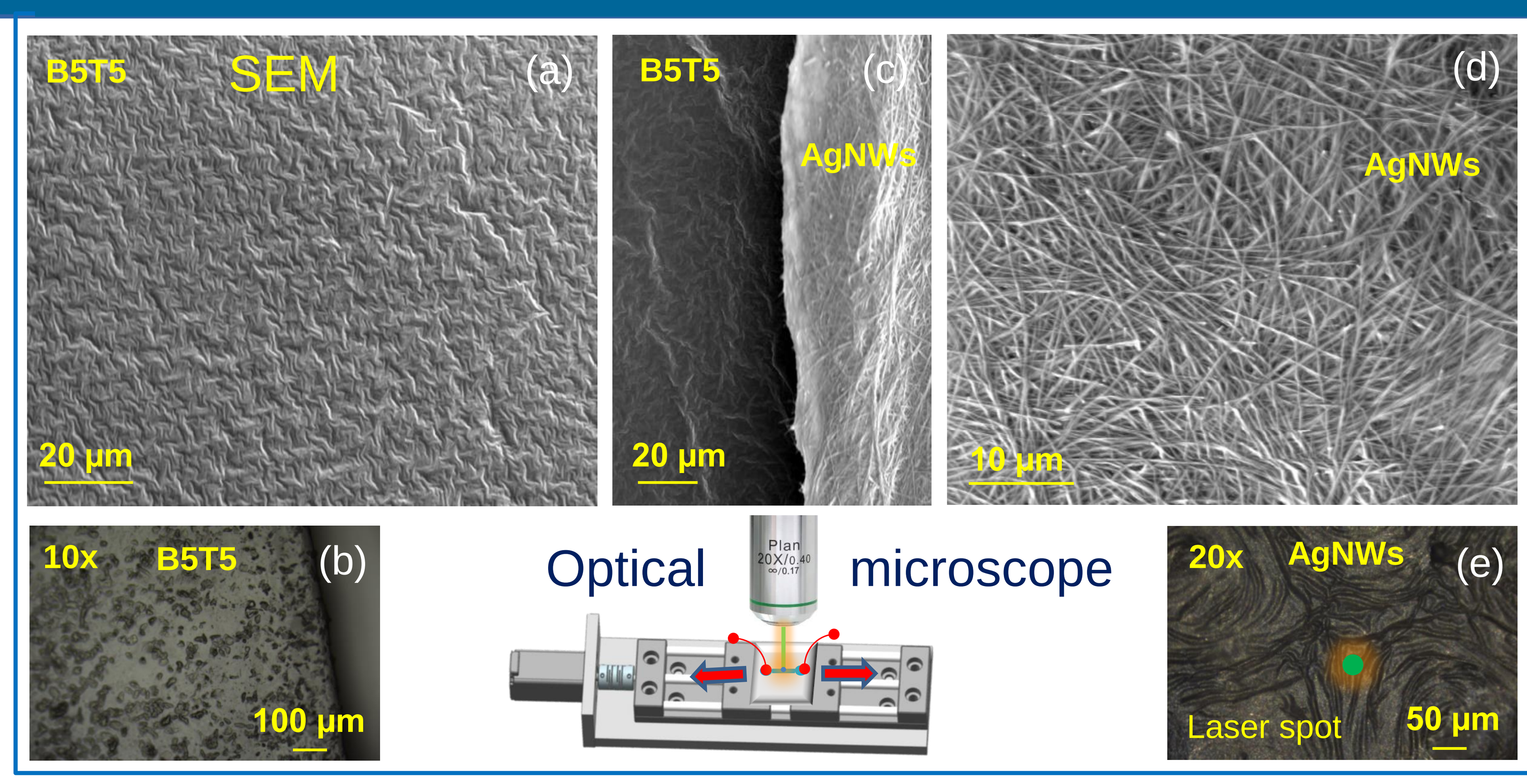
Due to their excellent electrical and mechanical properties, silver nanowires (AgNWs) are widely used in many fields such as optoelectronic devices, bio-nano sensors, and solar panels. Especially in the application to transparent conductive films (TCFs), silver nanowires have high visible light transmittance, high surface conductivity and mechanical flexibility due to their nano-scale size effect, and become the most likely alternative to soot tin oxide.

The aim of this work is to characterize the morphology of a AgNWs flexible conductive film through a scanning electron microscope (SEM), Raman spectroscopy and electrical measurements, and to study the changes in the AgNWs on the surface of a basement membrane undeformed and under tensile strains.

PREPARATION



MORPHOLOGY

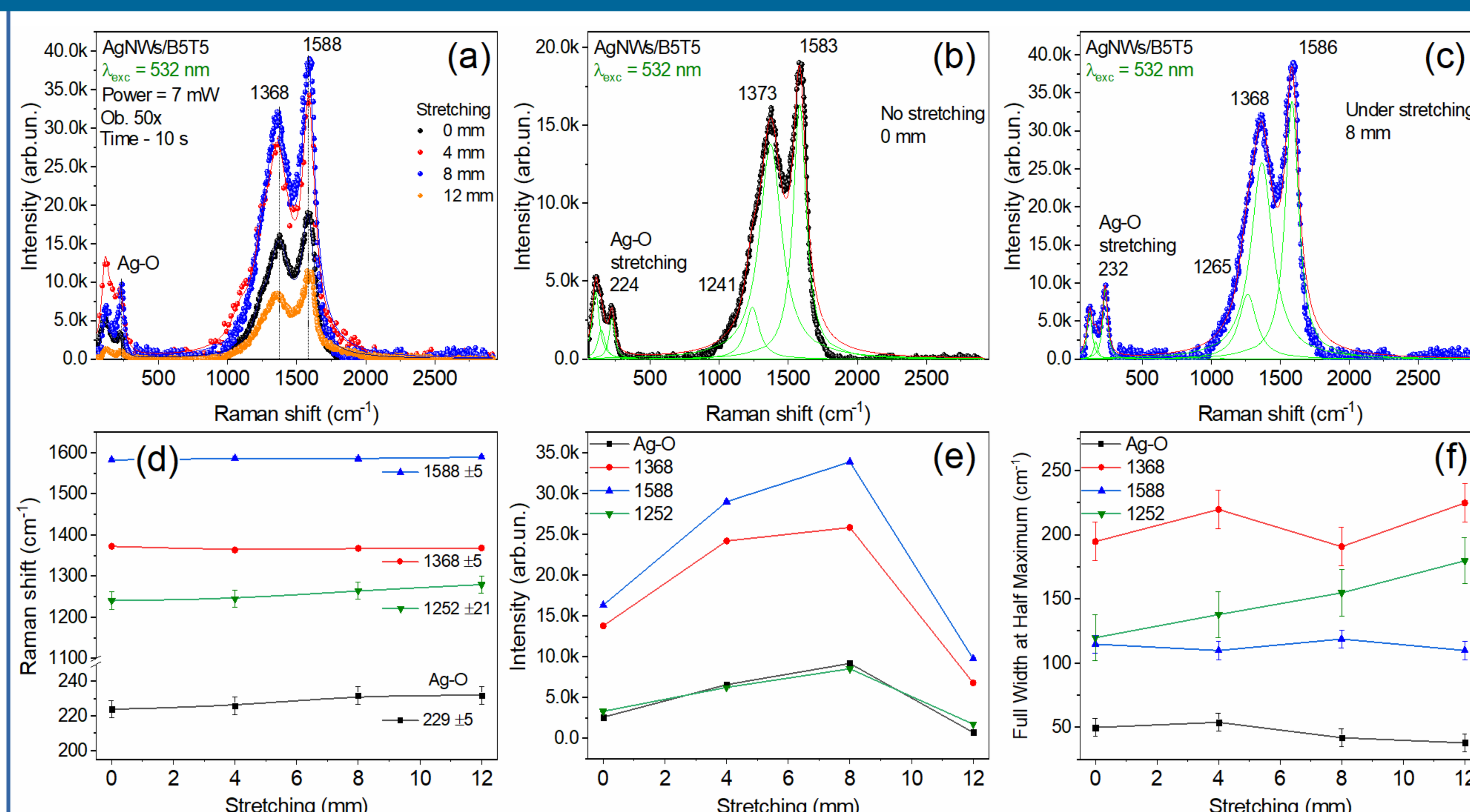


SEM (a) and optical (b) surface morphology of light-cured flexible substrate film (B5T5). Surface morphology at the boundary of the AgNW area and uncovered B5T5 film (c). SEM (d) and optical (e) surface morphology of AgNWs on B5T5.

RESULTS AND DISCUSSION

In this investigation, we used the drop cast method to achieve natural and random distribution of the AgNWs on flexible substrate without destroying their lengths applicable for creating flexible conductive films. The initial research was to prepare a flexible substrate. We used different proportions of light-curing liquids, cured by a UV lamp, and selected substrate films suitable according to viscosity, hardness and surface smoothness. Afterward, this flexible film was covered by AgNWs through a stencil to give a controlled shape and allowed to dry at room temperature.

The Raman analysis of the bands of AgNWs on a B5T5 membrane under variable stretching shows minor change, because the AgNWs is not affected when the membrane is stretched. This is may be due to the fact that the AgNWs do not interact with the membrane and keep their shapes unchanged and, hence, the crystal lattice does not change. This is also confirmed by the unchanged FWHM of the band at 232 cm^{-1}, which corresponds to the Ag-O bond vibration. Other bands almost do not change too. Any deviations of FWHM in the Figure are perhaps related to displacement of the detection point during stretching, which is evident when estimating the error being quite significant. This is also confirmed when considering the change in the intensities under 0, 4, 8, 12 mm stretching of a 20 mm film. The change in the intensities can be related to both a change in the substrate shape and the concentration of AgNWs on the surface.



Raman spectra of AgNWs films stretched by 0, 20, 40 and 60 percent (a-c) and their analysis (d-f). The deconvoluted spectra of the upstretched (b) and stretched (c) AgNWs.

CONCLUSIONS

1. The light-cured elastic substrates were prepared for creating flexible conductive films.
2. The morphology of the flexible conductive films shows random distribution of the AgNWs on elastic substrates.
3. The Raman analysis of the bands of the AgNWs on an elastic substrate under variable stretching shows minor changes. It was suggested that minor changes are related to both inhomogeneous distribution of AgNWs over the surface and the fact that the AgNWs do not interact with the membrane, keeping their shapes unchanged.

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