Synthesis of pencil-like silver nanowires through a water-mediated polyol process and its applications in nonlinear plasmonics

RIES, Hokkaido Univ. [1], KU Leuven [2], Yamagata Univ.[3], Toray Research Center, Inc. [4], ○Tomoko Inose[1], Shuichi Toyouchi[2], Akito Masuhara[3], Yasuhiko Fujita[2,4], Kenji Hirai[1], Hiroshi Uji-i[1,2]

E-mail: inose@es.hokudai.ac.jp

Silver nanowires (AgNWs) are one of the most interesting and useful metal nanostructures due to their unique electronic, thermal, and optical properties. The development of AgNW synthesis has been incentivized by their potential applications, such as plasmonic waveguide-based remote sensing and super resolution/highly sensitive microscopy/spectroscopy, including atomic force microscopy (AFM), tip-enhanced Raman scattering spectroscopy, and surface enhanced Raman scattering spectroscopy in a single live cell, which is known as plasmonic endoscopy. In addition to these applications, nonlinear optical effects (NLO) of metal nanostructures such as second harmonic generation (SHG) and/or wave-mixing, called nonlinear plasmonics, have recently attracted researchers because of their high sensitivity and ultrafast response, enabling to scale nonlinear optics down to nanometre scale. AgNWs are one of the most promising candidates for NLO applications due to their excellent plasmonic waveguiding properties which could provide a unique point light source at the nanoscale for super-resolution microscopy. For this kind of application, the end morphology of nanowires plays a crucial role in NLO properties.

So far, polyol synthesis of AgNWs has been widely studied in order to control the diameter and length of AgNWs. Several researchers have focused on AgNW synthetic conditions to further improve the polyol process in terms of yield and/or control of diameter/length of the final products. However, less attention has been paid to control of the end morphology, although it plays a crucial role in the aforementioned applications.

In this contribution, we introduce an active engineering of AgNW end morphology to enhance and control NLO response. We will show a critical effect of a small amount of water present in the polyol reaction on end morphology. An appropriate amount of water in the synthesis provides AgNWs with very sharp end morphology in the yield over 90%. We demonstrate highly consistent, enhanced NLO responses on sharp-end AgNWs owing to tight confinement of SPPs at the end, which is promising for nonlinear plasmonic waveguiding and as a point light source for super resolution spectroscopy/microscopy.