Lowered Melting Point of Polyvinylpyrrolidone Bound 1D Ag Nanowires

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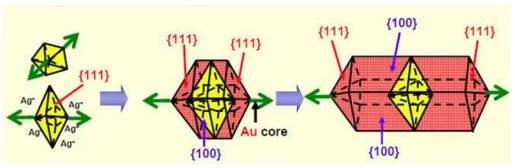
Research Target

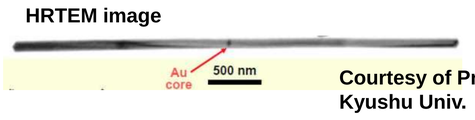
- Prepare long thin Ag nanowires
- Possible effect of surface-bound polyvinylpyrrolidone to lower the melting point of Ag nanowires

Growth mechanism from Au NP



Au NP — Lattice mismatch is only 0.25% — Elongation of Ag NW

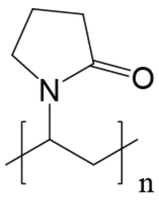
HRTEM image



Courtesy of Prof. Tsuji, Kyushu Univ.

Directional-Growth Control Agent:

polyvinylpyrrolidone (PVP)



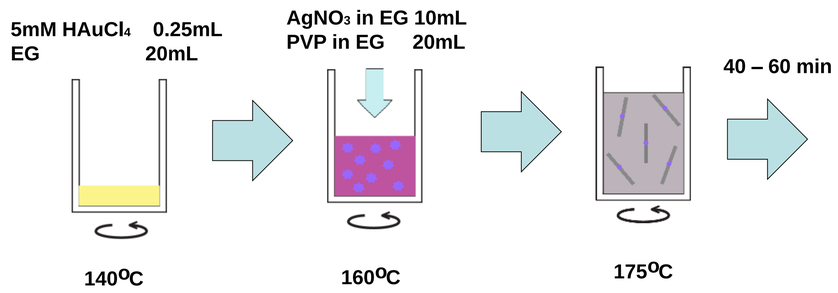
Solvent & Reducing Agent:

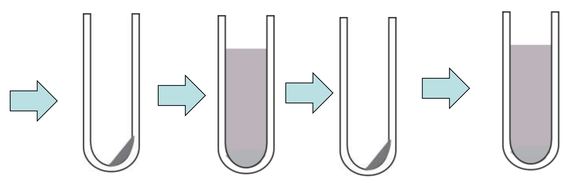
Ethylene Glycol (EG)

$$2\ \begin{matrix}CH_2OH\\|\\CH_2OH\end{matrix} \rightarrow \begin{matrix}CH_3C=O\\|\\CH_3C=O\end{matrix} + 2H_2O + 2H^+ + 2e^-$$

Preparation of Ag NW from Au NP Seeds

Au NPs serve as Xtal seed for Ag NWs



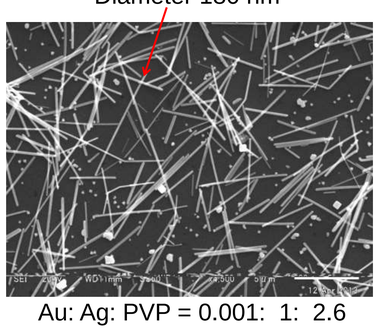


Centrifuge twice -> Wash out EG

Ag NW Suspension in 2-propanol

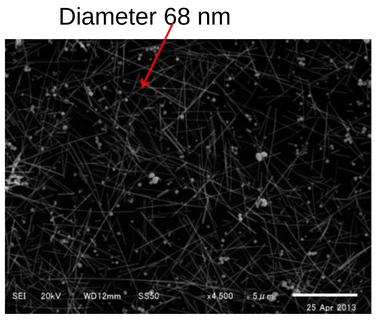
Controllable NW Diameter

Diameter 180 nm



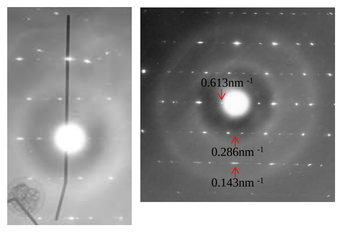
Au: Ag: PVP = 0.001: 1: 2.6 molar ratio

Diameter 68 nm



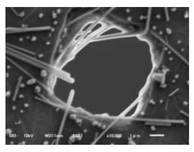
Au: Ag: PVP = 0.001: 0.9: 2.45 90% 95%

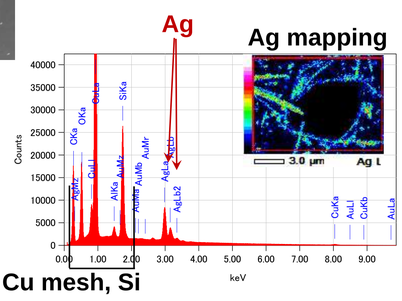
Electron Diffraction



Superposition with real image

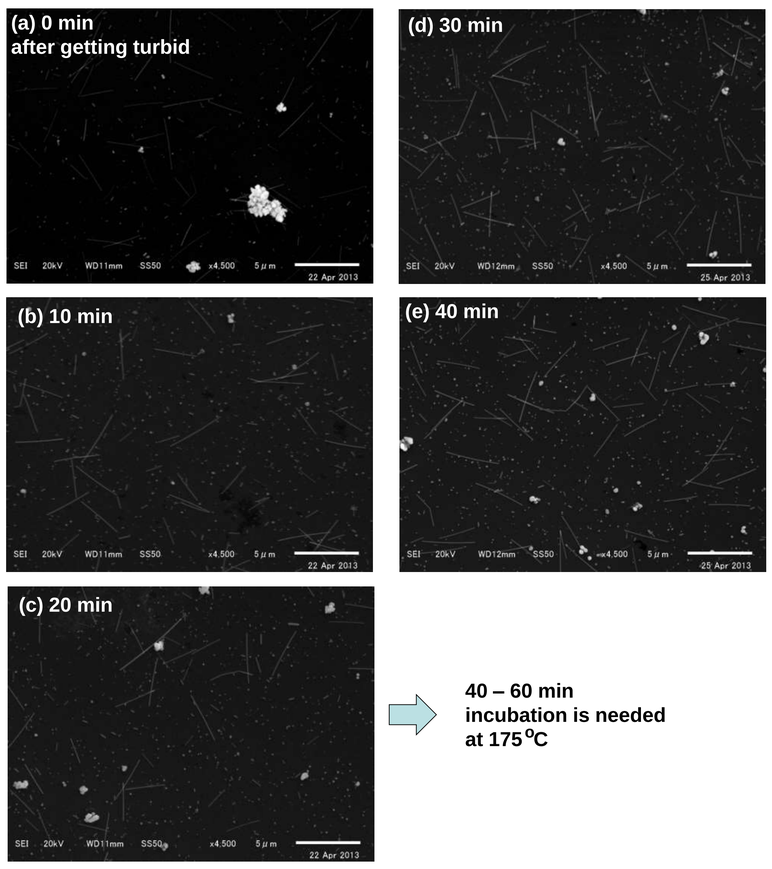
TEM EDX Analysis





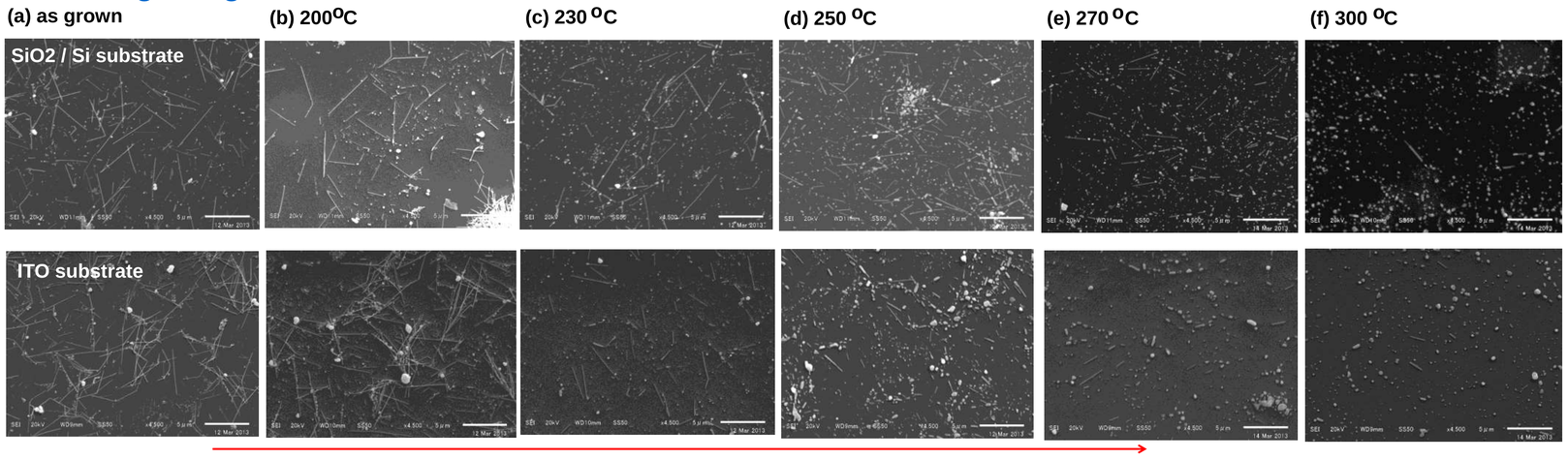
bg: C, Cu mesh, Si

Gradual Accumulation of Long NWs

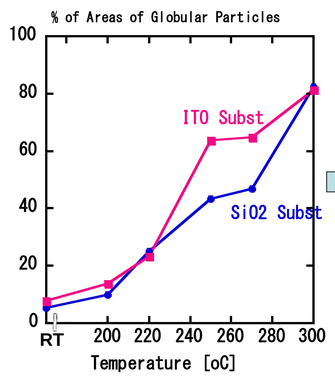


40 – 60 min incubation is needed at 175°C

Melting of Ag NWs



Ag NWs were melted to separate droplets



Au/Si Eutectic Formation is Excluded:

Lowered T_m

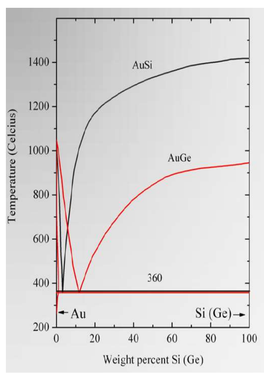
T_m = 240°C on ITO

T_m = 270°C on SiO_2

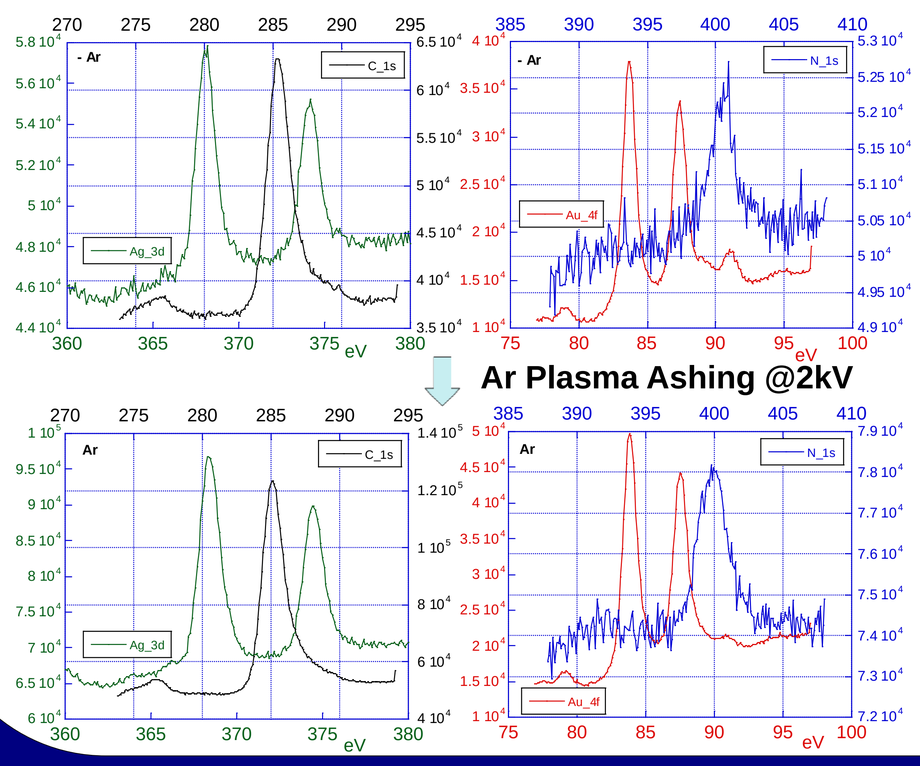
cf. T_m(Ag) = 961°C

T_m(Au) = 1063°C

Not due to Au/Si Eutectic Formation



Ar Plasma Ashing: removal of bound PVP



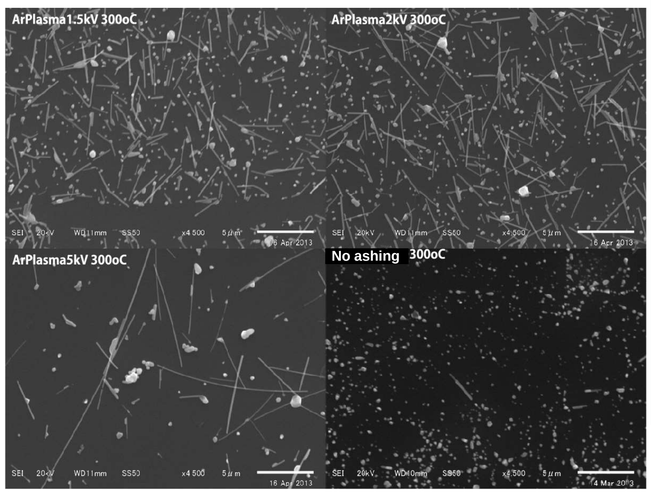
XPS Elemental Analysis

Ag 100 -> 100% (assumed)

C 100 -> 98%

N 100 -> 70% → **removal of bound PVP**

Au 100 -> 45%



Conclusion

- Ag nanowires with controllable diameter (60 – 200nm) were successfully prepared with intrinsic crystallographic registry.
- Ag nanowires with surface bound PVP layers showed lowered melting temperature down to 250 oC.
- Ar plasma ashing removed bound PVP layers partially, leading to raised melting temperature.