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Title: Single-Walled Carbon Nanotube Growth by alcohol catalytic CVD using Platinum-Group Metal Catalysts

Abstract: In general, single-walled carbon nanotubes (SWCNTs) are synthesized by chemical vapor deposition (CVD) at 700-900°C using Fe, Co and Ni catalysts. However, due to Ostwald ripening of catalyst particles, the uniformity of the SWCNT diameter is not sufficient, which is not preferable for electronics applications. In addition, reduction of the growth temperature is desired for realization of SWCNT devices compatible with LSI manufacturing processes. In this study, we performed SWCNT growth by alcohol catalytic CVD using platinum-group metal catalysts (Ru, Rh and Pt), since these metals have high-melting points ($> 1700^{\circ}\text{C}$), and reduction of Ostwald ripening is expected. By optimizing the growth condition, SWCNTs were grown from these catalysts at the growth temperature between 500 and 700°C. Irrespective of the catalyst metals, the diameter and chirality distribution became narrower, as the growth temperature decreased. In particular, the diameters of most SWCNTs grown from Pt catalysts were below 1 nm and their diameter distribution was quite narrow [1]. On the other hand, SWCNTs were grown from Rh catalysts even at 300°C, which is the lowest temperature record of SWCNT growth [2]. We will also discuss growth mechanism of SWCNTs from these platinum-group metal catalysts.

[1] T. Maruyama et al. *Carbon* 96 (2016) 6.

[2] T. Maruyama et al. *Carbon* 116 (2017) 128.