Preparation of single-helix and super-elastic CMCs by catalytic CVD process

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Carbon microcoils (CMCs) are a kind of vapor growth carbon fibers, which have a 3D-helical/spiral and amorphous structure with a coil diameter of micrometer orders, CMCs have a good mechanical property and conductive property and are a kind of new material expected to be used in many fields such as electromagnetic wave absorption, sensors, etc. In this study, in order to improve characteristics of CMCs, we performed the preparation of single-helix CMCs (SH-CMCs) using alumina-supported iron-nickel alloy catalysts, we also prepared super-elastic CMCs (SE-CMCs) by decreasing gas flow rates, comparing to conventional regularly coiled CMCs.

Synthesis process

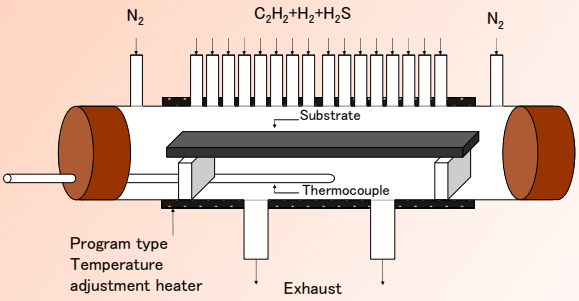

Fig.. 1. Reaction tube for the preparation of CMCs.

SEM image of CMCs

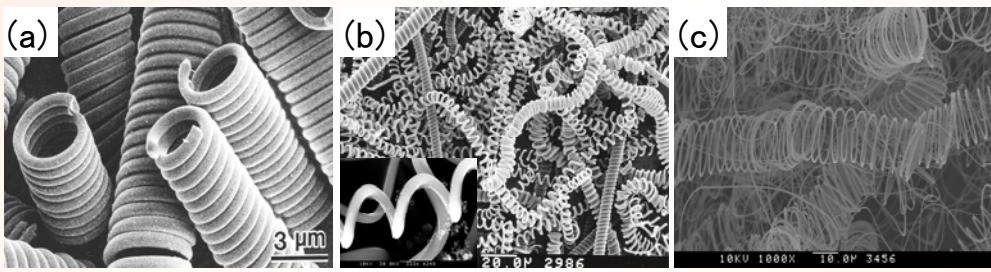

Fig. 2. SEM image of (a) typical CMCs (conventional regularly coiled CMCs) (b) SH-CMCs (c) SE-CMCs

SEM image of SH-CMCs

To paint the catalyst on the substrate by brush

Catalyst: Fe:Ni = 9:1 + alumina

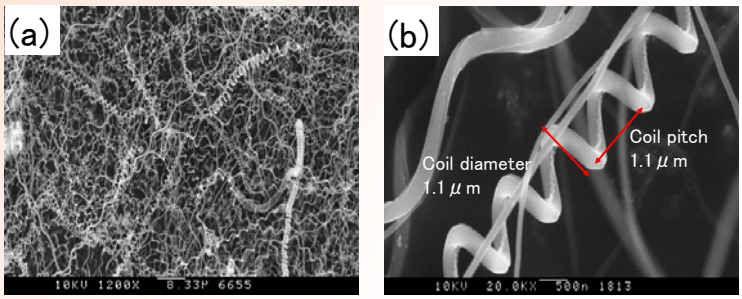

Fig. 3. SEM image of SH-CMCs (a) overall view (b) enlarged view

To deposit the catalyst on the substrate by ultrasonic treatment

Catalyst: Fe:Ni = 9:1 + alumina

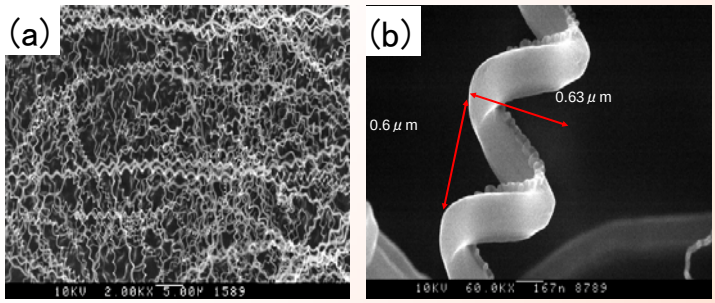

Fig. 4. SEM image of SH-CMCs (a) overall view (b) enlarged view

Distribution chart of the coil diameter and pitch

Catalyst: Fe:Ni = 8:2 + alumina

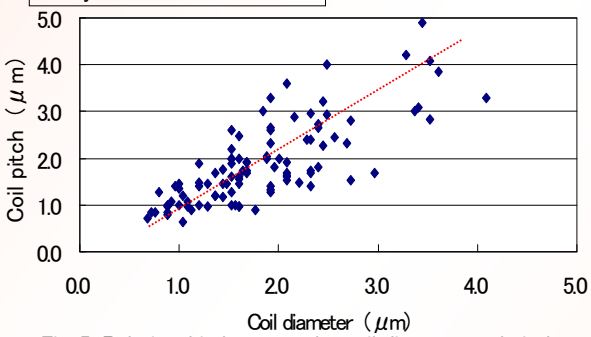

Fig. 5. Relationship between the coil diameter and pitch

SE-CMCs

Influence of H_2S flow rate for SE-CMCs

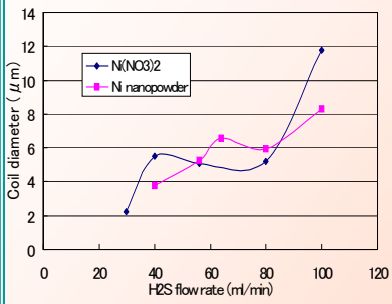

Fig. 6. Relationship between diameter and H_2S flow rate.

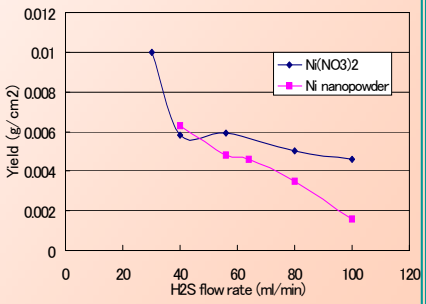

Fig. 7. Relationship between yield and H_2S flow rate.

Conclusion

SH-CMCs

- With increasing the ratio of nickel to iron (other preparation conditions unchanged, reaction temperature, 710℃), SH-CMCs with larger coil pitches and coil diameters could be obtained.
- The CMC yield grown by ultrasonic treated catalyst (on the substrates) is higher than that grown by brush-painted catalysts (on the substrates).
- Various alloys with different Fe/Ni ratio were used (9:1; 8:2; and 7:3), it was found that the ratio of coil pitch versus coil diameter in the all obtained the SH-CMCs was about 1.

SE-CMCs

- With increasing the H_2S flow rate (other preparation conditions unchanged, Ni nanopowder or $Ni(NO_3)_2$ as a catalyst, reaction temperature, 770℃), SE-CMCs with larger coil diameters and few yield could be obtained.