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# Preparation, and electronic properties of nickel chloride-filled single-walled carbon nanotubes

**Marianna V. Kharlamova**
**Department of Materials Science, Lomonosov Moscow State University, Moscow, Russia**

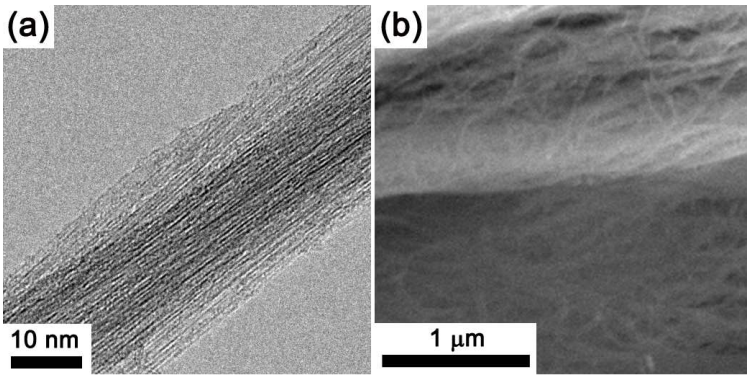
## INTRODUCTION & AIM

Single-walled carbon nanotubes (SWCNTs) are filled with metal halides to modify their electronic properties. Metal halides are filled in SWCNTs with a melt method. They have various melting temperatures, and different protocols have been optimized for the filling of SWCNTs with metal halides. Nickel chloride ($NiCl_2$) is a unique metal halide. Filling SWCNTs with nickel chloride is of large interest to researchers because its encapsulation in SWCNTs leads to p-doping. Nickel chloride has a high melting temperature (1001ºC). It is important to develop a method for filling SWCNTs with nickel chloride [1-3].

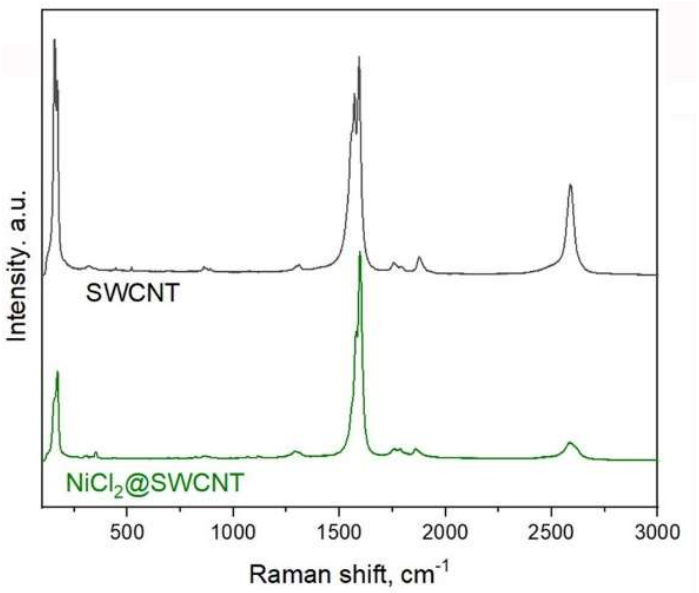
## METHOD

In this work, we submit a filling protocol for SWCNTs with nickel chloride, filling the melted compound in the SWCNTs. The protocol was conducted at 1101ºC for 10 hours. The subsequent cooling down period was carried out at rates of 0.02-1ºC/min to crystallize nickel chloride in the SWCNTs. The electronic properties of the nickel chloride-filled SWCNTs were investigated with Raman spectroscopy and X-ray photoelectron spectroscopy (XPS).

## RESULTS & DISCUSSION




The transmission electron microscopy (a) and scanning electron microscopy (b) images of the nickel chloride-filled SWCNTs.




The Raman spectra of the pristine, and nickel chloride-filled SWCNTs acquired at the laser wavelength of 785 nm.

## CONCLUSION

The Raman spectra of the nickel chloride-filled SWCNTs showed large shifts in the peaks and alterations in their intensities. The C 1s XPS spectra showed a shift of the peak in lower binding energies. The observed modifications are the result of the variations in the Fermi level of the nickel chloride-filled SWCNTs. It is shifted down in the filled SWCNTs due to the work function differences between nickel chloride and the SWCNTs.

## REFERENCES

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