A new composite material consisting of MnTe matrix with embedded $MnBi_2Te_4$ quantum dots

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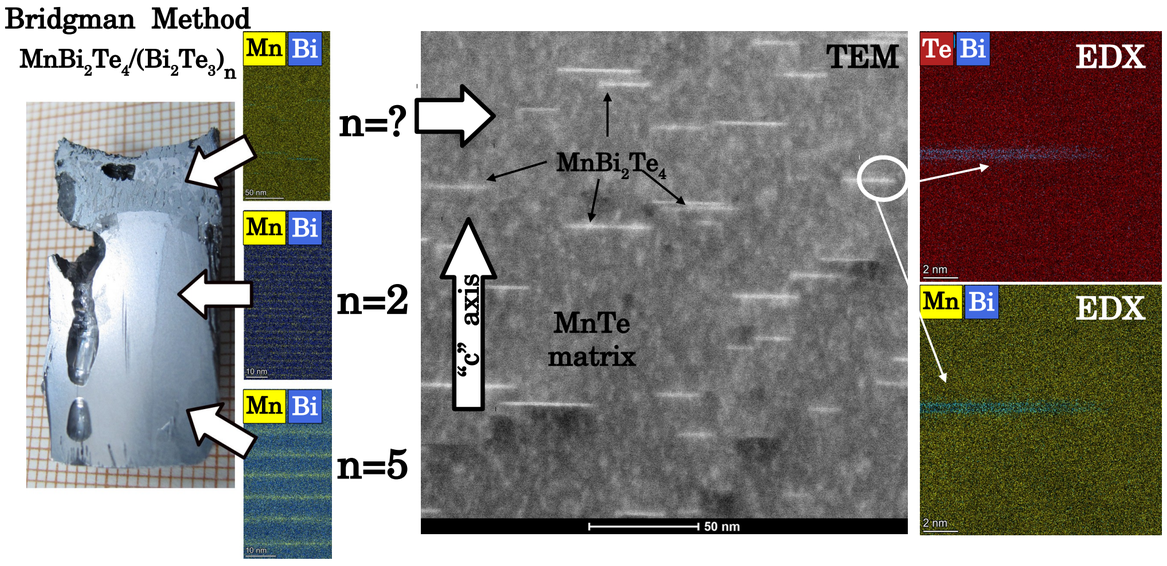
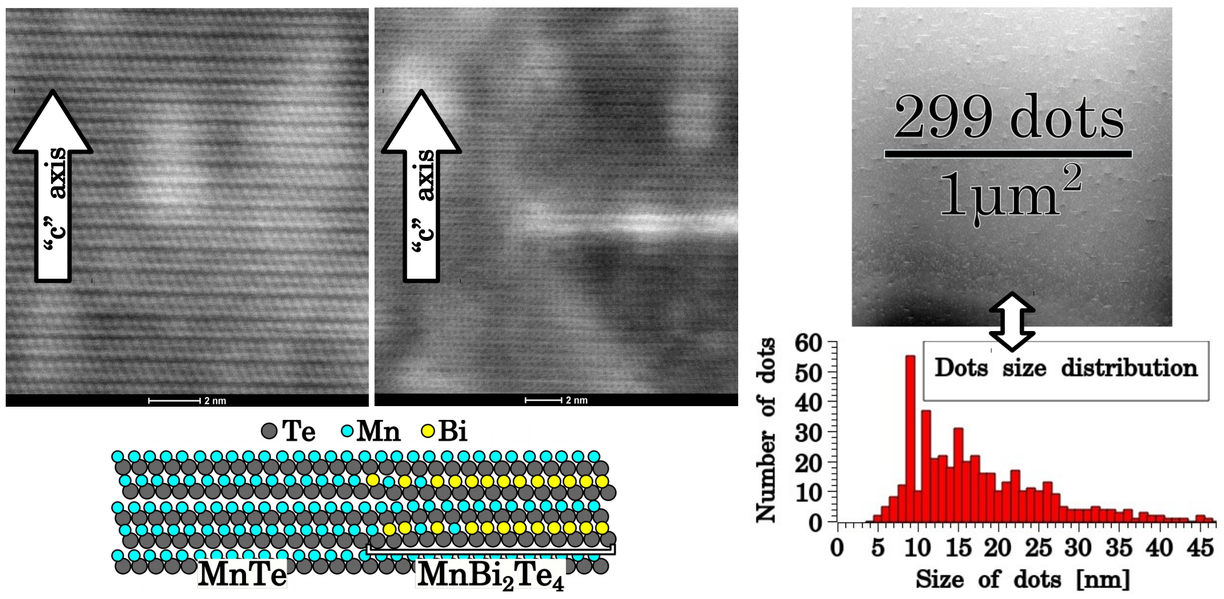
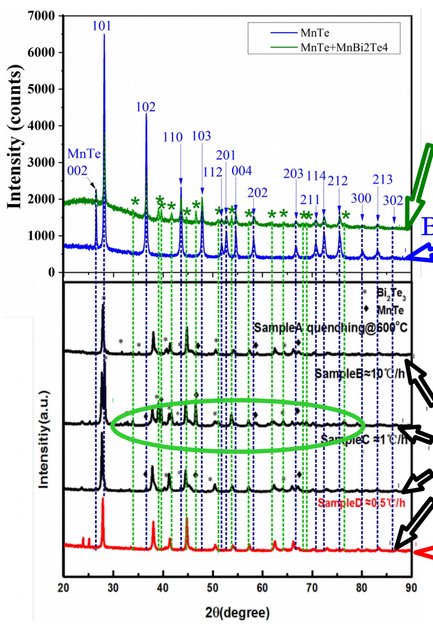
Structure of the new material MnTe matrix + $MnBi_2Te_4$ dots

Inverted Vertical Bridgman Method

$MnBi_2Te_4/(Bi_2Te_3)_n$







X-ray diffraction (XRD) pattern of powder samples.

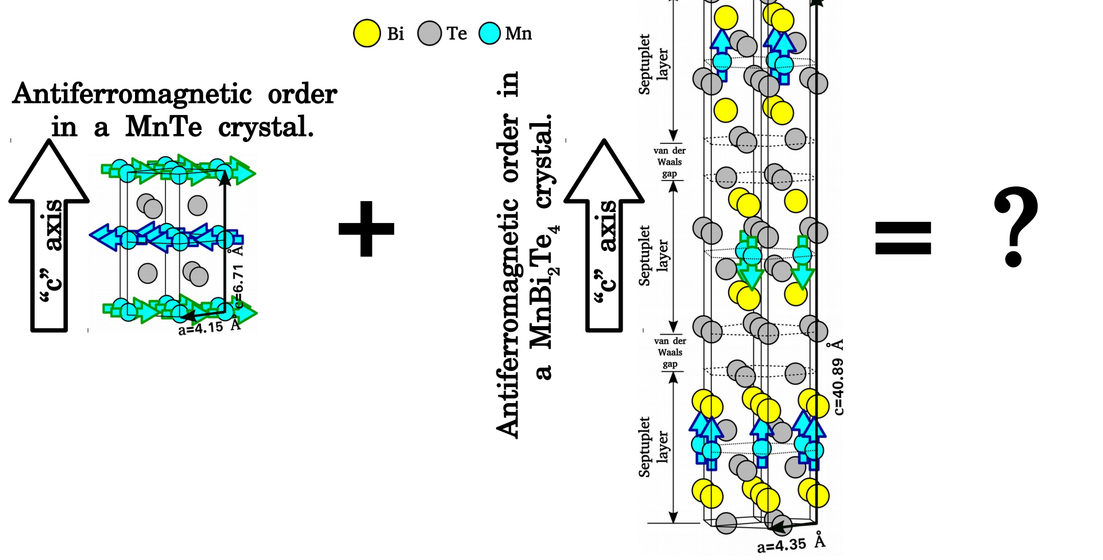
Green - XRD pattern of MnTe matrix phase, ✱ is distorted phase of a $MnBi_2Te_4$.

Blue - XRD pattern of pure MnTe phase, NiAs-type structure (I43m), lattice constants a = 4.15 Å, c = 6.71 Å.

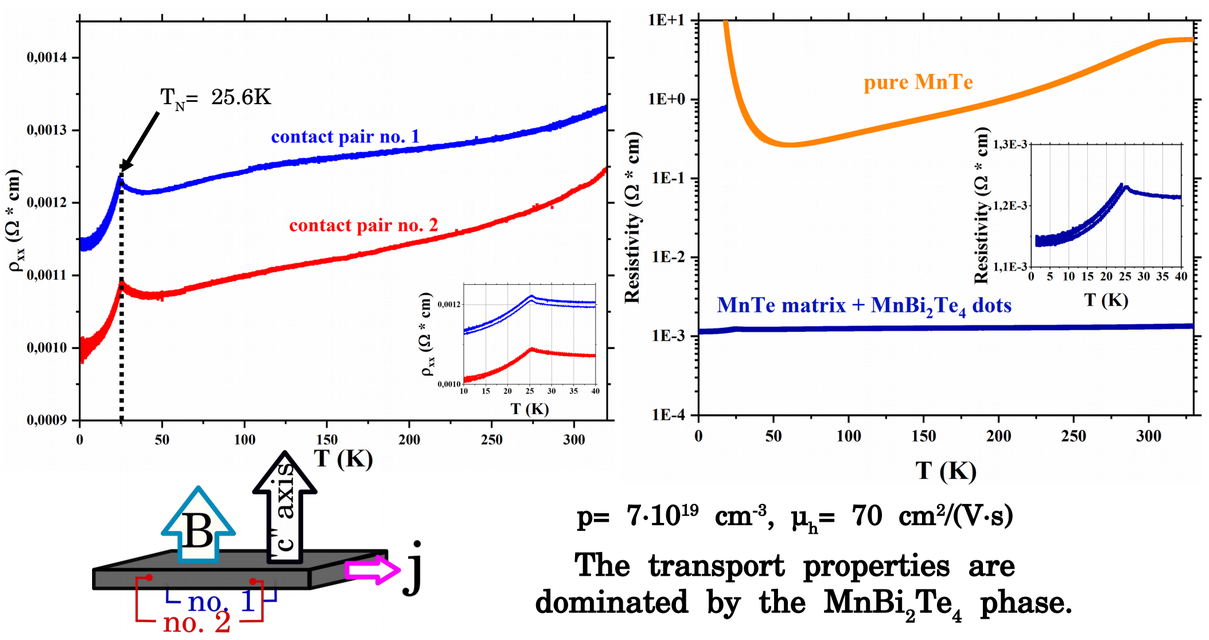
S. Yu, K. Zhao, X.S. Yang, et al. J Supercond Nov Magn **35**, 1221–1228 (2022).

sample name	growth method	chemical composition - energy dispersive X-ray spectroscopy			element ratio
	Cooling Rate (585 ~ 600 °C)	Mn (At%)	Bi (At%)	Te (At%)	Mn:Bi:Te
Sample A	Quenching at 600 °C	11	25	64	1:2.2:5.8
Sample B	10 °C/h	11.6	31.4	57	1:2.7:4.9
Sample C	1 °C/h	13.1	35.8	51.1	1:2.7:3.9
Sample D	0.5 °C/h	13.6	28.3	58.1	1:2.1:4.2

$MnBi_2Te_4$ rhombohedral crystal structure (R3m), lattice constants a = 4.35 Å, c = 40.89 Å (layer d=13.4Å).

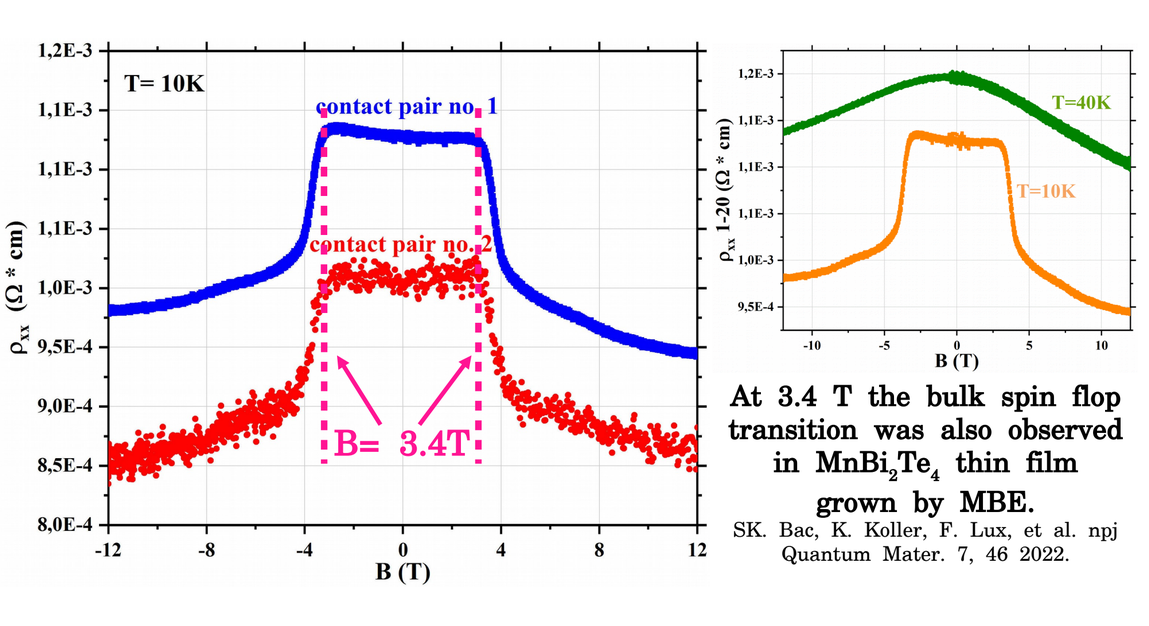


Transport properties of MnTe matrix + $MnBi_2Te_4$ dots



$p = 7 \cdot 10^{19}$ cm^{-3}, μ_h = 70 $cm^2/(V \cdot s)$

The transport properties are dominated by the $MnBi_2Te_4$ phase.



At 3.4 T the bulk spin flop transition was also observed in $MnBi_2Te_4$ thin film grown by MBE.

SK. Bac, K. Koller, F. Lux, et al. npj Quantum Mater. 7, 46 2022.

Conclusions

- The mechanism of formation of $MnBi_2Te_3$ dots in the MnTe matrix involves the replacement of manganese layers with layers of bismuth atoms.
- The crystallographic structure of the $MnBi_2Te_3$ dots is strongly distorted by the surrounding MnTe matrix.
- In this new material, there are two antiferromagnetic orders with the Neel vectors perpendicular to each other.
- In measurements of the dependence of remnant magnetization on temperature, four transitions are visible, related to:
  - for T_C= 13 K - ferromagnetic transition in an insulated single $MnBi_2Te_3$ layer
  - for T_N= 25.6-26.5 K - antiferromagnetic transition resulting from the interaction between $MnBi_2Te_3$ layers
  - for T_N= 86.5 K - antiferromagnetic transition in $MnTe_2$
  - for T_N= 307 K - antiferromagnetic transition in MnTe.
- The dominant carriers of electric current are holes with concentration of 10^{19} cm^{-3} and mobility about 70 $cm^2/(V \cdot s)$.
- The transport properties are dominated by the $MnBi_2Te_4$ phase.
- A spin-flop transition characteristic of antiferromagnetic $MnBi_2Te_4$ was observed at 3.4T.