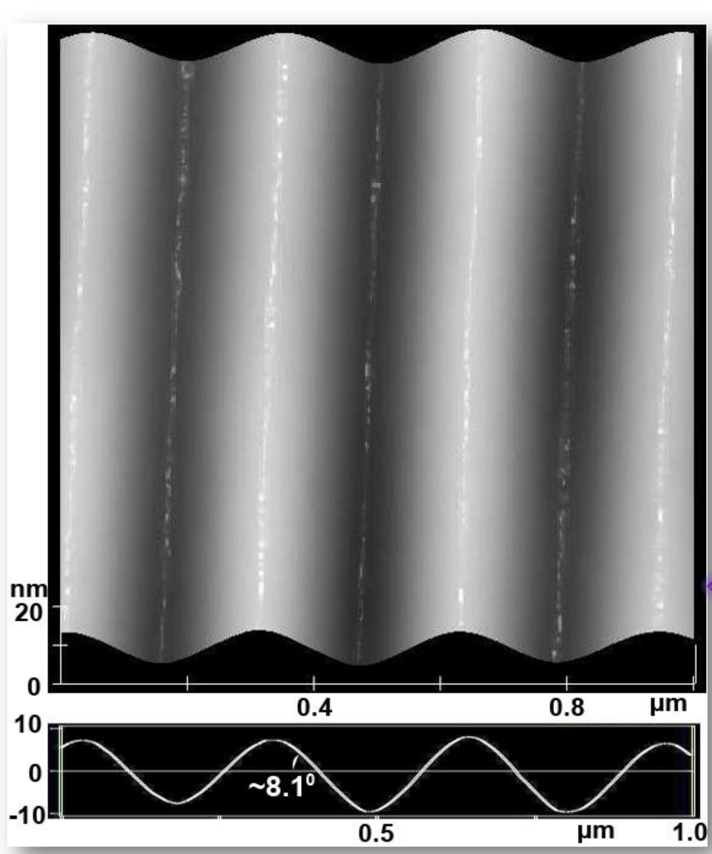
Hole transport in one dimensional aligned GeSi quantum dots at low temperatures

H. Y. Zhang, H. Yuan, B. Zhang, Z. Y. Zhong, Y. L. Fan, Z. M. Jiang
Surface Physics Laboratory (National Key Laboratory), Fudan University, Shanghai 200433, China

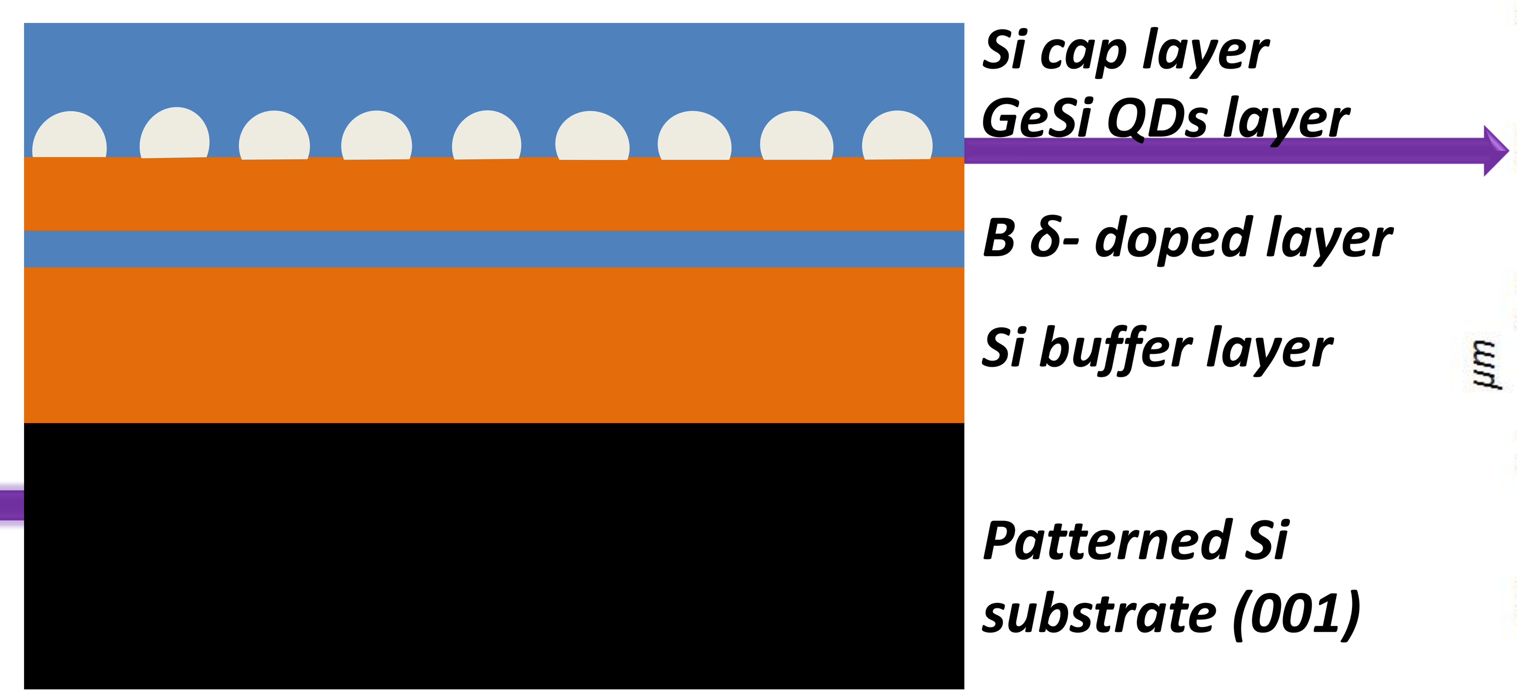
Introduction

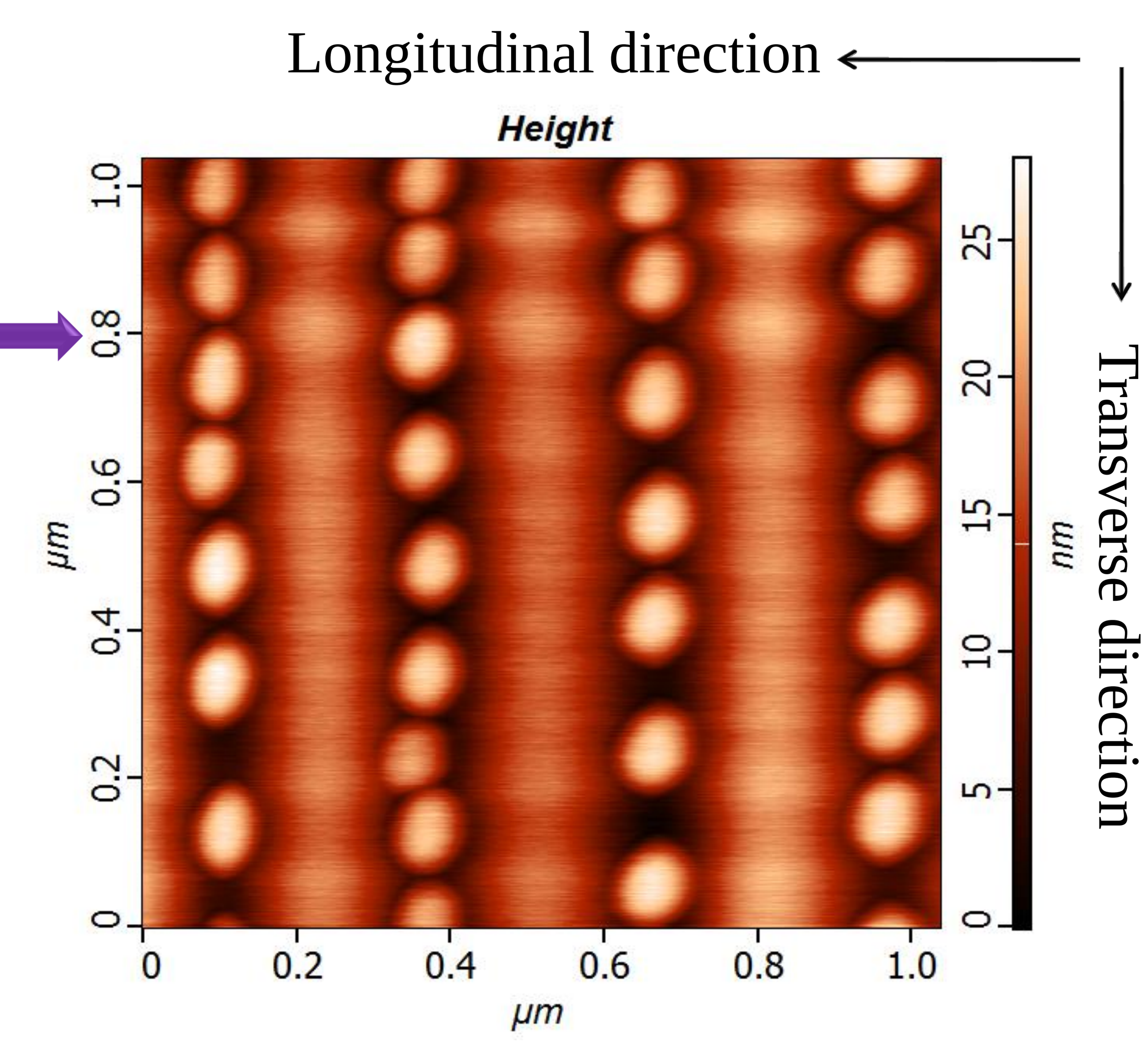
Electronic phenomena in self-assembled quantum dots (QDs) have interested researchers for more than one decade. Small differences in size, shape, and position of the QDs lead to variations in the energies of electrons (or holes) occupying the quantum-confined orbits. The carrier hopping process between these occupied states has contribution to the conduction at low temperatures. In general, self-assembled QDs are dislocation-free, but random in spatial distribution. Under some growth conditions long-range ordered QDs can be realized by self-assembling QDs on 1D trench-patterned substrate, but electric transport properties in those ordered QDs structures are rarely reported.

Sample Preparation



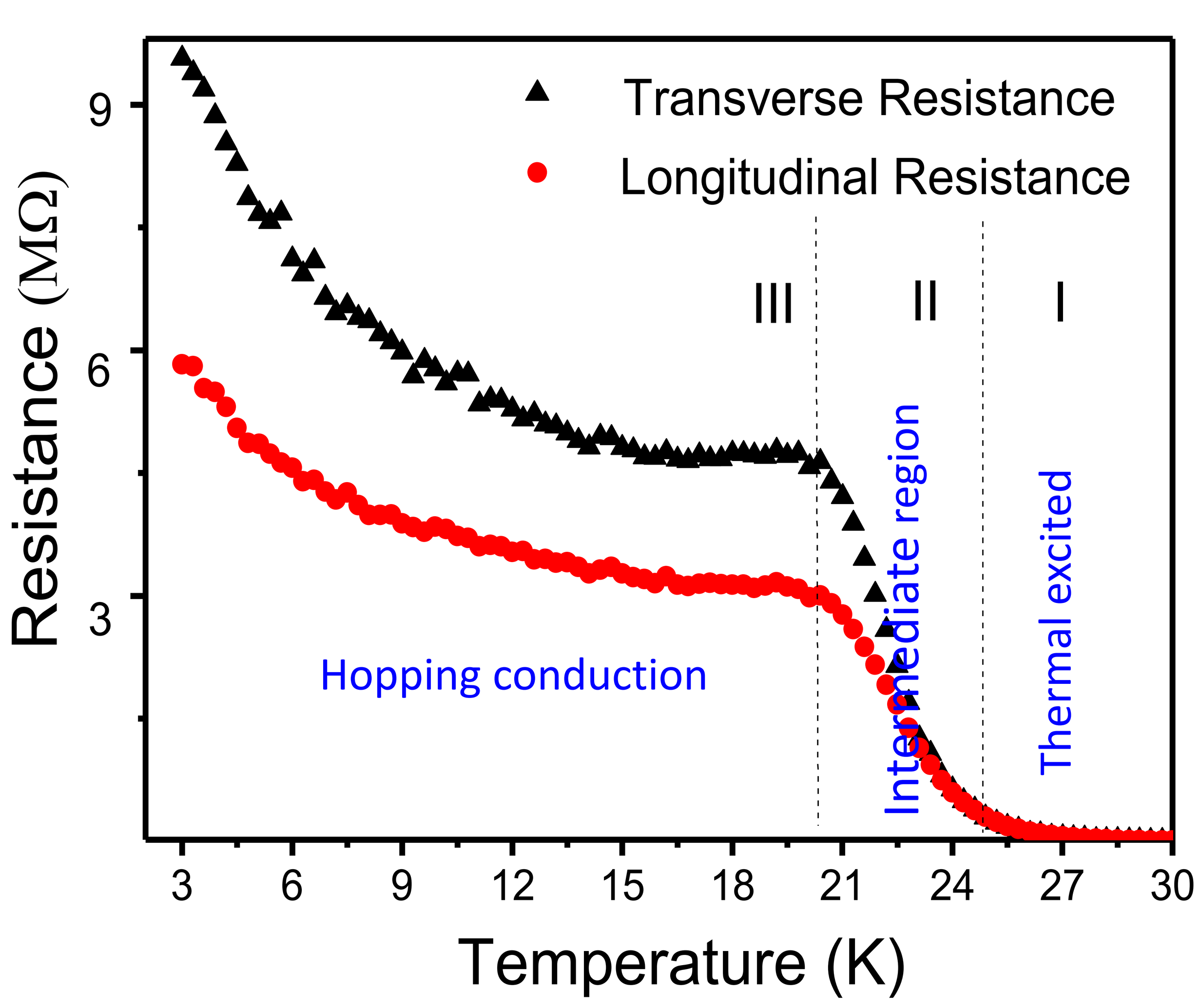
Substrate pattern





AFM image of QDs layer

Temperature dependent resistance

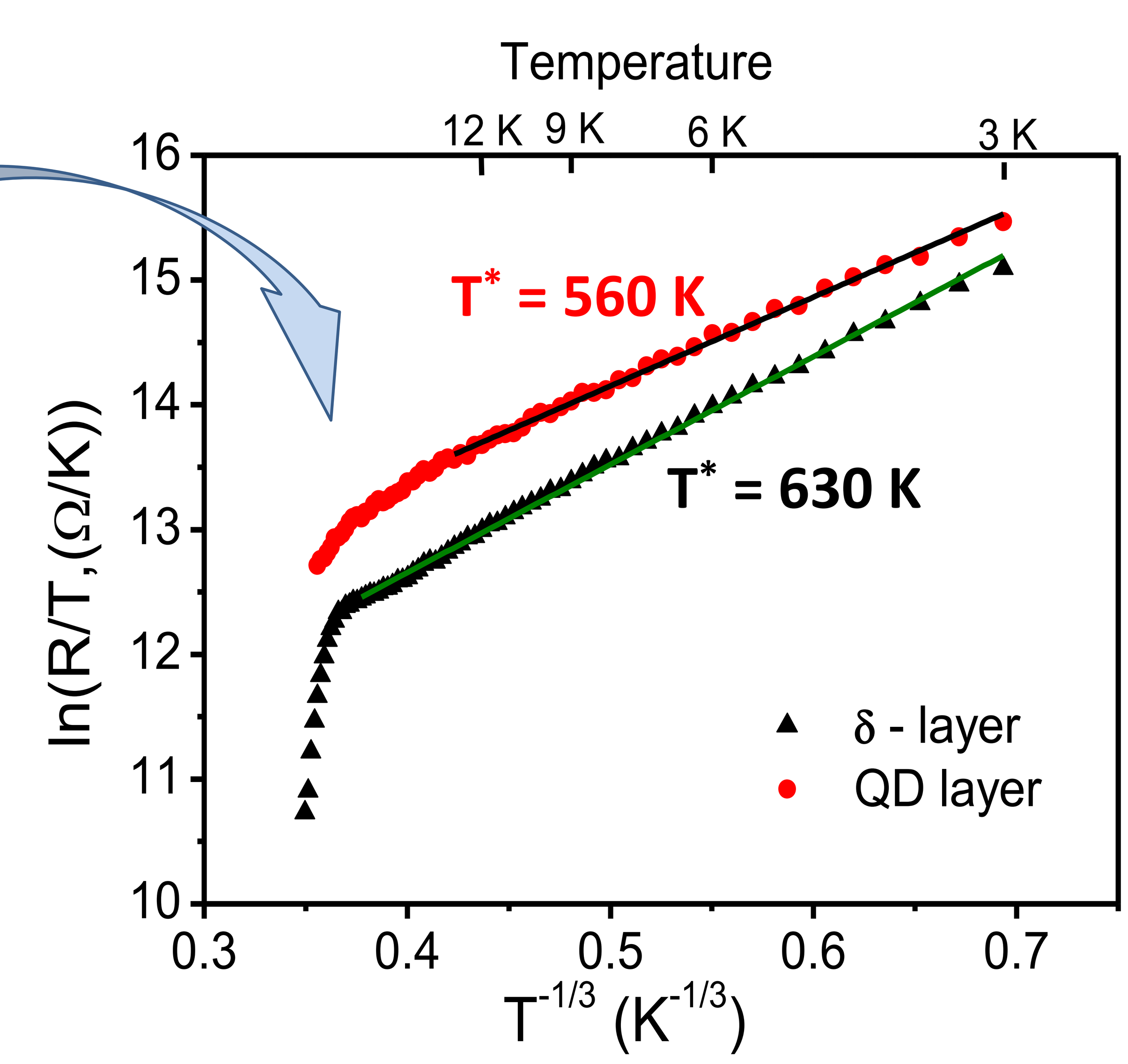


Two conductive layers are in parallel

$$R_{Longitudinal} = R_{\delta} \, // \, R_{QDs}$$

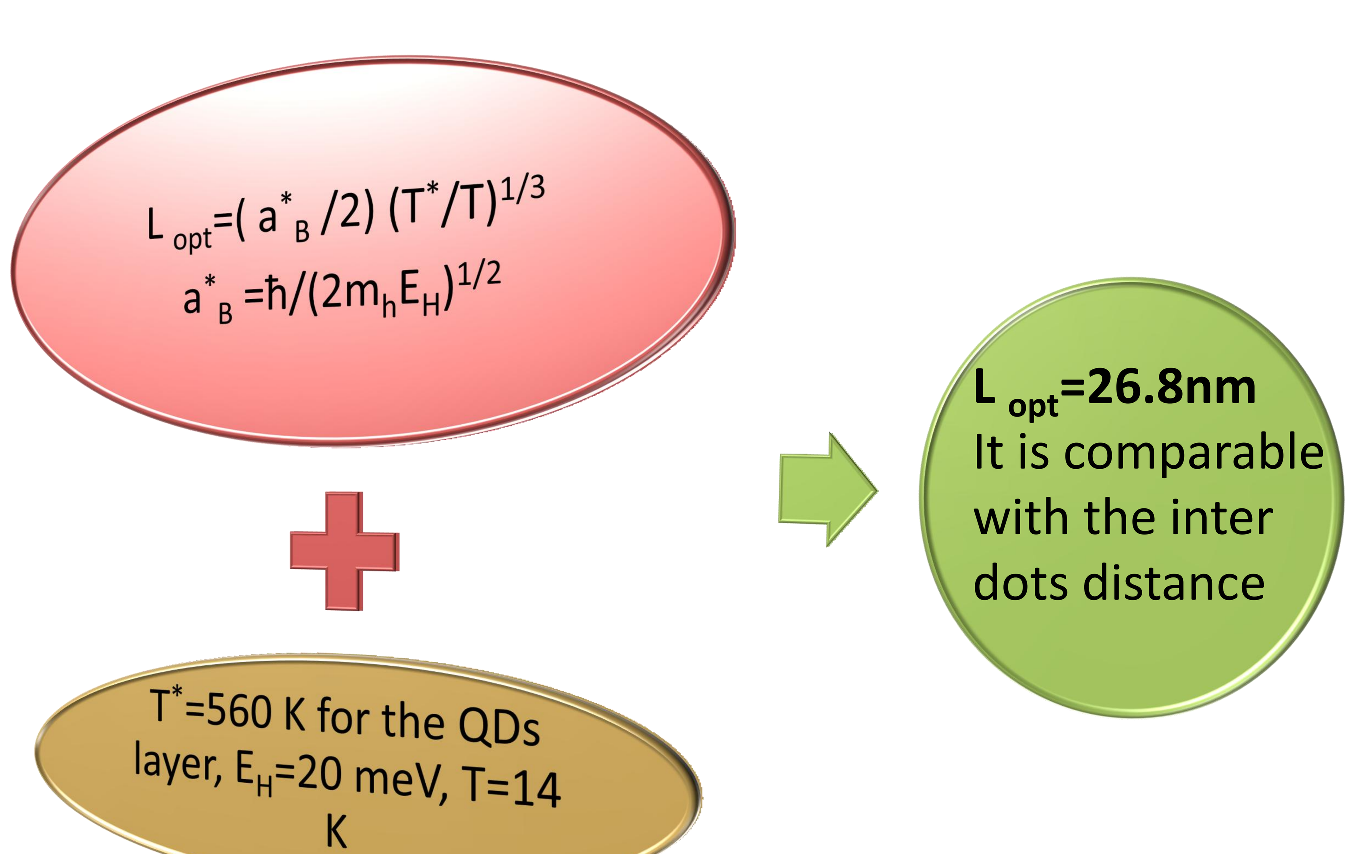
Two dimensional Mott's VRH

$$\sigma(T) \approx \frac{1}{T}\exp[-(T^*/T)^{1/3}]$$



Discussion

Hopping distance



Conclusion

1. One dimensional aligned GeSi QDs along 1D trenches have been prepared.
2. Two conductive layers are suggested to explain the differences.
3. Both the temperature dependences of the resistances in the two layers are two dimensional Mott's variable range (VRH).
4. L_{opt} increases with the temperature decreasing, it is therefore reasonable to believe that the carrier hopping could occur between QDs along the same chain.