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## Enhanced conductance in Superconductor Semiconductor junctions at zero voltage.

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An enhancement of the zero-voltage conductance of a niobium-silicon junction is found at very low temperatures. This enhancement is a result of quantum interference of electrons, near the superconductor semiconductor interface, which results in an increase of Andreev reflection probability.

### 1. INTRODUCTION

At the interface between a normal metal (N) and a superconductor (S), a process called Andreev reflection [1] can occur: an incoming electron, with an energy below the superconducting gap, is reflected as a hole. This process will double the current, and therefore double the conductance. If a barrier exists at the S-N interface, the Andreev reflection probability will be smaller than 1, and in general energy dependent [2]. Experiments on Nb-InGaAs contacts [3] have shown a conductance enhancement at low voltages, which can not be explained by the simple normal metal-superconductor model introduced by Blonder *et al* [2]. In refs. [4–7] the suggestion was made that impurity scattering could lead to enhancement of the Andreev reflection probability, which can account for an enhanced conductance.

### 2. EXPERIMENTS

To be able to study a single SN interface, we followed two different approaches. We used degenerately doped Si membranes ( $8 \cdot 10^{19} \text{cm}^{-3}$  B) of either 50 nm or 500 nm thickness, which were made as described in ref. [8]. It was shown previously that for the 50 nm thin membranes, the thickness of the Si layer is small compared to  $l_\phi$ . Fig. 1 gives a schematic view of the samples. In the 500 nm membrane sample, the two Nb electrodes are so far apart (with respect to  $l_\phi$ ), that

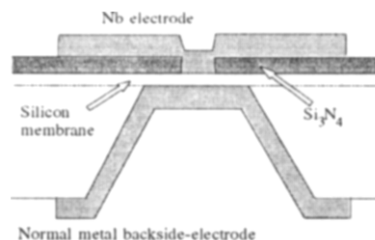


Figure 1. Schematic view of the samples used. A 50 nm Si membrane, with on top a Nb electrode, and a normal metal backside electrode of either W or Au. The backside electrode for the 500 nm samples is Nb.

the junction essentially consists of two decoupled S-N interfaces in series. The second system is a double barrier SININ' structure with a 50 nm Si layer. In these samples we have a Nb contact on top, and a normal metal, either W or Au, as backside electrode. Although in this system the two barriers are not decoupled, because of the small Si layer thickness, we are able to study a single SN interface in this manner. Fig. 2 shows the differential conductance of the Nb-50 nm Si-W junction, for various temperatures.

A clear zero-voltage conductance enhancement, with respect to the conductance at higher temperatures, is observed, which drops rapidly with increasing voltage. The conductance peak has completely disappeared at 1.2 K. For lower temperatures it saturates below 100 mK. These observations are in agreement with earlier measure-

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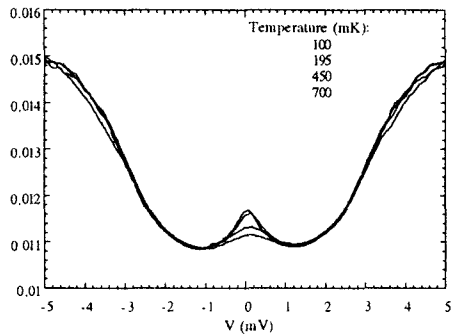


Figure 2. Differential conductance of a Nb-Si-W junction, as a function of voltage, for different temperatures.

ments on the Nb-500 nm Si-Nb junctions. Magnetic field dependent measurements are shown in Fig. 3. The influence of the magnetic field on the zero-voltage conductance is qualitatively the same as that of temperature. The conductance enhancement is suppressed completely at a field of approximately 100 mT, which is in good agreement with predicted values of the critical field [7]. In the Nb-Si-Au junctions, where the normal metal contact resistance is smaller than the Nb-Si contact resistance (in the Nb-Si-W junctions is the normal metal contact resistance dominant), we find an even greater enhancement of the zero-voltage conductance. Despite the low transparency of the S-N interface (of the order of 0.1), the zero-voltage conductance in those samples is higher than the normal state conductance. Similar conductance curves were measured recently by Heslinga *et al* [9], who used point contact spectroscopy on a Si membrane with a Nb backside contact.

### 3. CONCLUSIONS

Our measurements show a clear enhancement of the zero-voltage conductance at low temperatures and zero magnetic field. Further analysis of the experimental observations requires the application of the ideas of ref. [4-7] to the specific geometry of our samples. Especially with respect to impurity scattering and scattering at the bar-

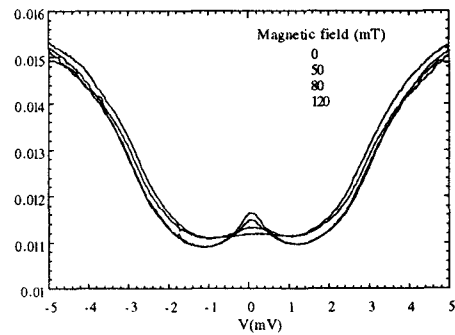


Figure 3. Differential conductance of a Nb-Si-W junction, as a function of voltage, for different applied magnetic field, at 90 mK.

riers.

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### REFERENCES

1. A. F. Andreev. *Zh. Eksp. Teor. Fiz.*, 46:1823, 1964. [Sov.Phys. JETP 19, 1228 (1964)].
2. G. E. Blonder, M. Tinkham, and T. M. Klapwijk. *Phys. Rev. B*, 25:4515, 1982.
3. A. Kastalsky, A. W. Kleinsasser, L. H. Greene, R. Bhat, F. P. Milliken, and J. P. Harbison. *Phys. Rev. Lett.*, 67:3026, 1991.
4. B. J. van Wees, P. de Vries, P. Magnée, and T. M. Klapwijk. *Phys. Rev. Lett.*, 69:510, 1992.
5. C. W. J. Beenakker. *Phys. Rev. B*, 46:841, 1992.
6. I. K. Marmoros, C. W. J. Beenakker, and R. A. Jalabert. preprint, 1993.
7. A. F. Volkov, A. V. Zaitsev, and T. M. Klapwijk. To appear in *Physica C*, 1993.
8. W. M. van Huffelen, M. J. de Boer, and T. M. Klapwijk. *Appl. Phys. Lett.*, 58:2438, 1991.
9. D. R. Heslinga, S. E. Shafranjuk, H. van Kempen, and T. M. Klapwijk. preprint, 1993.