Evidence for high temperature superconducting phases in PdH

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Abstract

New superconducting phases with a high critical transition temperature (T_c) have been found in stable Palladium-Hydrogen (PdH_x) samples for stoichiometric ratio x=H/Pd≥1, in addition to the well-known low critical transition temperature ($0 \leq T_c \leq 9$) when x is in the range ($0.75 \leq x \leq 1.00$). New measured superconducting phases with critical temperature in the range 51K $\leq T_c \leq$ 295K occur. This T_c varies considerably with every milli part of x when x exceeds unit. A superconducting critical current density $J_c \geq 6.1 \cdot 10^4$ Acm^{-2} has been measured at 77K with $H_{DC} = 0$T.

Key words:
PdH; HTSC; new superconducting material

1. Introduction

In 1972 PdH_x was shown to be a superconductor at 6.6K [1] [2]. Later the maximum T_c of 9K was found at the stoichiometric ratio x=1 [3][4]. It is an open question [5] if for x≥1 the PdH system has a greater T_c in respect to the previous measurements[1-5]. It is not easy to produce PdH_x samples with high and stable x, in order to perform resistivity measurements versus temperature. In fact the H^+ in interstitial sites of Pd lattice is extremely mobile [5] and a decreasing of x is natural during temperature cycles. Moreover the superconductivity in Pd-H(D,T) system shows an inverse isotopic effect [6][7][8] that suggests complicated electron-phonon interaction and because the superconductivity appears only when x ≥ 0.6, it is extremely important to know and mantain constant the stoichiometry. In this paper resistive superconducting transition in presence of DC magnetic field and critical current density at 77K will be discussed for PdH_x wires with high x.

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2. Experimental Results

H has been loaded into Pd wires (diameter of 50μm; length of 30cm) used as cathode in an electrochemical cell. Cell geometry , electrolyte, loading procedure and experimental set-up have been described in the reference [9]. The x value was obtained indirectly by ac electrical resistance measurement (1KHz, 20mA) of the PdH_x during the dc electrochemical hydrogen loading process [9][10]. The measured electrical resistance of PdH_x is a function of the mean stoichiometric ratio x with a well known resistence curve at room temperature [10].

The superconducting critical temperature is measured by ac resistance measurement versus temperature using a thermally controlled He gas flow cryostat provided with a superconducting magnet. The ac electrical current amplitude was 2mA and the frequency 107Hz. After H loading, the wire sample was wrapped around a glass cylinder, then the two ends were welded with Ni wire using silver print because of the brittleness of the sample. After, the Ni wires were soldered to four copper wire contacts for the resistance measurement. Figure 1 shows two different electrical resistance

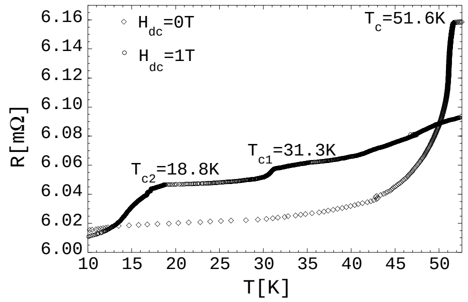

Fig. 1. Superconducting resistive transition for a 30cm long PdH_x sample

transition curves for the same sample. In plot (A) a T_c at 51.6K is observed with $H_{DC} = 0$T. Plot (B) shows a double transition with T_c's at about 31.3K and 18.8K when $H_{DC} = 1.0$T. When an external magnetic field of $H_{DC} = 0.1$T was applied, the superconducting transition temperature was still observed at approximately 51.6K. There is more than one superconducting phase, due to the non homogeneity of x inside the sample. Small decreases of PdH resistance show that only a little portion of the wire is in the superconducting state. Different resistance values with or without DC magnetic field should indicate the presence of magnetic resistance due to a complicated Fermi's surface [11].

Critical current density measurements in LN_2 have been done on other samples using a different experimental set-up. In fact, to prevent the wire break (Pd spot welded on Pt contact) after the electrochemical H loading procedure, the same sample holder has been cooled down to LN_2 temperature. A dc power supply has been connected to the wire and the dc voltage drop along the wire has been measured in grounded configuration. The measured voltage drop amplitude (10^{-4} V/cm) is higher than the usual value used in this measurement (10^{-6} V/cm) because of the grounded electrical set-up. Figure 2 shows the I-V characteristics of two PdH wires highly H loaded and stable at room temperature, then quenched at LN_2 temperature. Increasing the dc electrical current, the dc voltage drop remains almost constant. The resistance remains null up to a dc electrical current of 1.15A then the resistance starts to increase. The critical current density, at earth magnetic field, of about $J_c \approx 6.1 \cdot 10^4$ Acm^{-2} has been shown in fig.2. The second wire shows (fig.3) a greater critical current density $J_c \geq 6.1 \cdot 10^4$ Acm^{-2} . We can only write the disequality because of the experimental limitation on electrical current. It is important to underline that the total wire length (6 cm) shows a superconducting behaviour at LN_2 temperature for both samples.

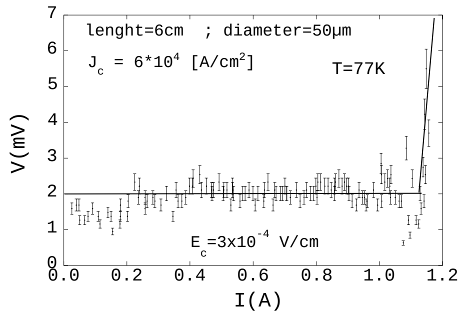

Fig. 2. Critical current measurement in PdH_x samples at LN_2 temperature

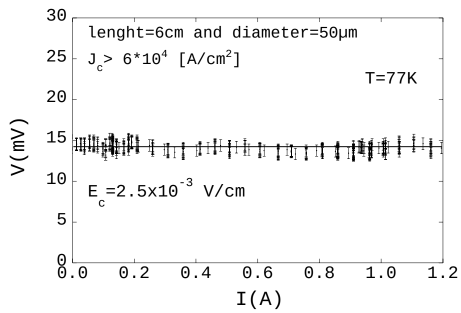

Fig. 3. Critical current measurement in a different PdH_x samples at LN_2 temperature

3. Conclusion

We present in this letter new superconducting phases in PdH system [12]. This finding has been reached thanks to the experimental procedure to obtain high and stable x in Pd. The critical current density at 77K seems promising for future technological applications.

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