

OPTICAL OBSERVATION OF IMPURITY BANDS IN DISORDERED BINARY ALLOYS BASED ON NICKEL

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Submitted 5 April 1972

ZhETF Pis. Red. 15, No. 12, 705 - 708 (20 June 1972)

The theory of binary alloys was based for a long time on the simplest representation of the rigid band [1], i.e., on the hypothesis that the conduction electrons of the alloy components lose their individuality completely in the common underformed band. The work of Lifshitz [2] initiated a new point of view, that the energy bands of the alloy components are formed while retaining appreciably their individual characteristics. Ehrenreich and co-workers [3] have demonstrated the possibility of quantitative calculations of the state-density curves of disordered alloys on the basis of the coherent-potential method. The coherent-potential method was used to calculate the density of the electronic states in real metallic paramagnetic [3] and ferromagnetic [4] binary alloys. One of the most important physical consequences of these studies was that narrow impurity bands with relatively high state density can occur near the boundary of the ground-state band. The shape and positions of the impurity-band boundaries depend on the degree of overlap of the pure metals, on the positions of the singularities in the initial bands, and on the impurity concentration. In particular, a typical case is the sharp increase of the density of impurity states above the boundary of the unsplit band.

We show in this paper that if we postulate a mechanism of indirect optical transitions from the ground-state band into the impurity band, then we can observe by an optical method the appearance of the impurity band in binary alloys, estimate its position and width, and also propose a method of reconstructing the state-density curve in the main metal as reflected in the impurity band.

The Beatty method was used to measure the optical characteristics of polycrystalline samples of the alloys 99%Ni - 1%Co, 97%Ni - 3%Co, 95%Ni - 5%Co, 99%Ni - 1%Mo, and 98%Ni - 2%Fe in the interval 0.5 - 2.0 eV at room temperature.

Figures 1 and 2 show the frequency dependences of the function $(\kappa\omega)^2 \epsilon_2$, which is proportional to the density of states, for all these alloys (ϵ_2 is the imaginary part of the dielectric constant, and x is the impurity concentration). The dashed curve in Fig. 3 shows the location of the impurity band in Ni-Co alloys relative to the state-density

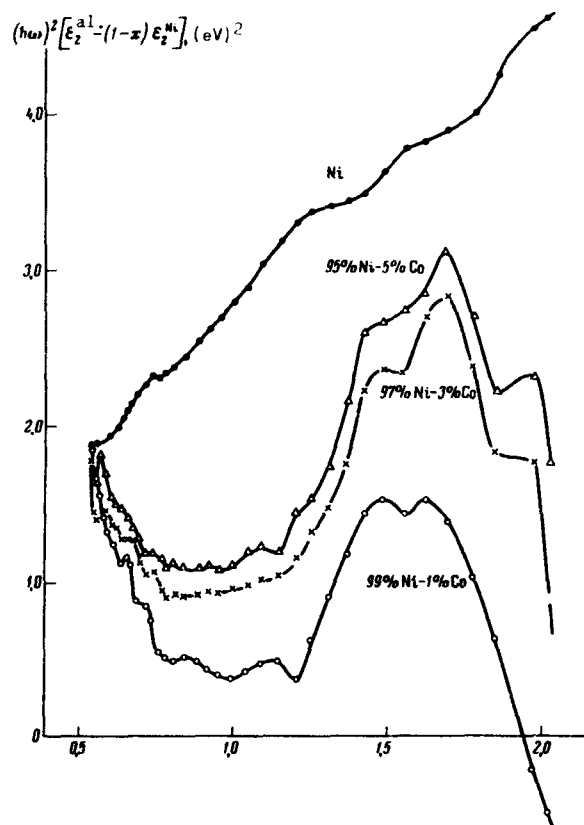


Fig. 1

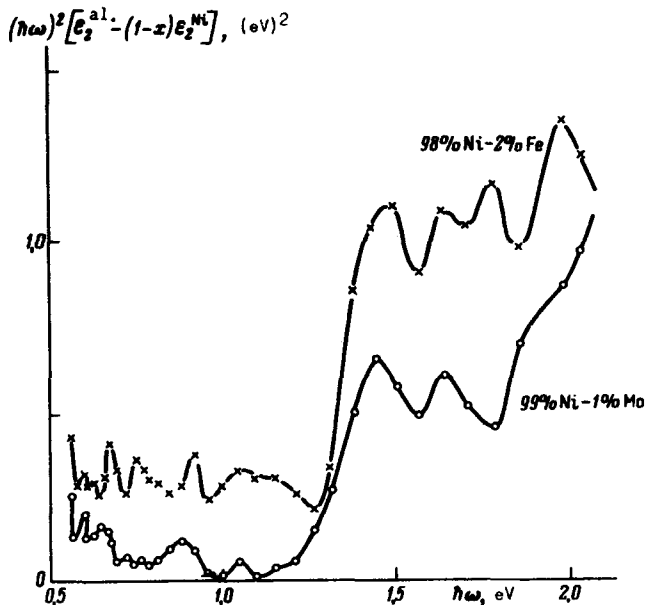


Fig. 2

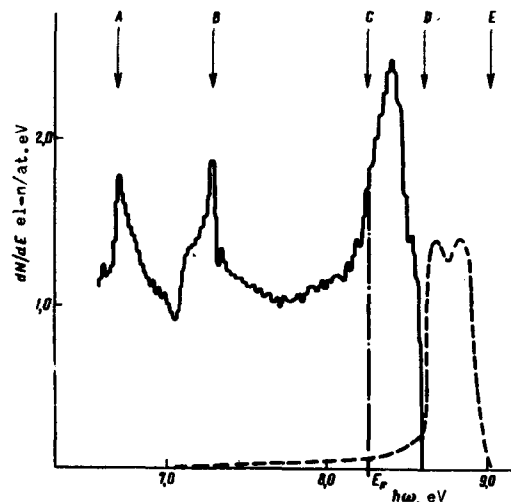


Fig. 3

curve of nickel, taken from [5], and makes it possible to present a satisfactory interpretation of the results. The shape of the impurity-band state-density curve near the edge of the unperturbed band agrees qualitatively with the results of the calculations performed in [2, 3], i.e., it is characterised by a sharp growth of the density of states above the edge of the ground-state band and by a structureless background with low density of states in the region of the ground-state band. The position of the high-energy edge of the impurity band was chosen by us on the basis of the following considerations: the first peak of the interband state density should correspond to a transition from the states near the Fermi level (C) into the impurity band. The long-wave edge of these transitions corresponds to the interval (C - D) and amounts to approximately 0.3 - 0.5 eV.

(The state-density curve shown in Fig. 3 corresponds to only one (IV) of the models considered by Zornberg [5].) We can therefore assume that the decrease of the interband state density, observed in Fig. 1 in the region 0.70 - 0.75 eV, corresponds to the short-wave boundary of this peak (C - E). From this we find that the width of the impurity band is approximately 0.3 - 0.4 eV. From this point of view, the presence of a second peak of the interband density of states in the region 1.3 - 1.8 eV corresponds to transitions from the peak B to the impurity band. The width of this peak, 0.5 - 0.6 eV, corresponds to the sum of the widths of the peak B (~ 0.2 eV) and of the impurity band (~ 0.4 eV).

The interband state-density curves for the Ni-Fe and Ni-Mo alloys (Fig. 2) can also be understood on the basis of the scheme of Fig. 3. The main singularity in the 1.2 - 1.4 eV region, due to the B \rightarrow D transitions and determined not by the character of the impurity band, but by the relative position of the peak B and of the edge of the ground-state band, is clearly observed for both alloys. Some characteristic differences between the curves for the Ni-Fe and Ni-Mo alloys in the regions 0.5 - 0.7 eV and 1.8 - 2.0 eV can be attributed either to the larger width of the impurity band or to the stronger influence of the Fe and Mo impurities on the form of the ground-state band. In addition, for Ni-Mo alloys in the 1.8 - 2.0 eV region there can be observed a contribution of the transition from the exchange-shifted peak B (by an amount on the order of

0.4 eV [5, 6]) of another spin subband of nickel to the exchange-unsplit impurity band.

We have thus presented direct experimental proof of the appearance, in a binary disordered alloy with small impurity concentration, of a relatively narrow impurity band localized near the edge of the ground-state band. In addition, observation of the interband density of the optical transitions into the impurity band provides a good method of investigating the curve of the density of states of the main metal, which is suitable for both ferromagnetic and non-ferromagnetic alloys.

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TWO-STEP PHOTODISSOCIATION OF AMMONIA MOLECULES EXCITED BY LASER RADIATION

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 Submitted 17 April 1972
ZhETF Pis. Red. 15, No. 12, 709 - 711 (20 June 1972)

1. We report here the first observation of two-step photodissociation of molecules excited by laser radiation. Two-step photoionization and photodissociation processes in atoms and molecules are considered in [1, 2] from the point of view of the selective action of laser radiation on matter. In the two-step photodissociation scheme, the monochromatic laser radiation excites selectively the molecules to the vibrational or electronic level (in this case, the vibrational level of the NH₃ molecule) and the simultaneously excited molecules are

Fig. 1. Experimental setup:

I - Pulsed CO₂ laser with transverse discharge (1 - total-reflection mirror of resonator (R = 10 m), 2 - laser tube, 3 - diffraction grating, 4 - plane-parallel plate, 5 - IKM-1 monochromator, 6 - mirrors, 7 - IR receiver, 8 - oscilloscope, 9 - lens (F = 200 mm), 10 - rotating prism). II - UV radiation block (11 - hydrogen lamp, 12 - condenser, 13 - modulator). III - Cell with ammonia. IV - Recording system (14 - MDR-2 monochromator, 15 - photomultiplier, 16 - oscilloscope).

