Functional Materials 7, No.3 (2000) 

# Optical investigation of the localized bands in the binary alloys of copper and 3*d* metals

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Optical properties of Cu–Fe, Cu–Co, and Cu–Cr copper-rich alloys obtained in a wide spectral region (0.5 to 4.95 eV) are summarized. An additional absorption associated with interband electron transitions from localized states of impurities to the Fermi level has been revealed in 1.0–1.9 spectral range. An electron structure model has been proposed for those alloys. According to the model, the energy bands in those alloys are almost undeformed and similar to copper ones while Fe, Co, and Cr impurities form localized *d* bands at a distance of about 1.0 to 1.6 eV from the Fermi level. For high impurity concentrations when the alloys are two-phase ones and consist of essentially pure Fe, Co, or Cr and Cu-based solid solutions with Cu content about 95 %, the experimental optical conductivity spectra $\sigma(h\nu)$ of the alloys have been shown to be defined by superposition of Fe, Co, or Cr spectra with that of the appropriate solid solution under corresponding weight coefficients.

Обобщены результаты исследований оптических свойств сплавов Cu–Fe, Cu–Co и Cu–Cr с высоким содержанием меди в широкой области спектра от 0,5 до 4,95 эВ. В диапазоне 1,0–1,9 эВ обнаружено дополнительное поглощение, связанное с межзонными переходами электронов из локализованных состояний примесей на уровень Ферми. Предложена модель электронной структуры исследованных сплавов. Согласно этой модели, энергетические зоны в этих сплавах почти не деформированы и подобны зонам меди, а примеси Fe, Co или Cr формируют локализованные *d*-зоны, отстоящие от уровня Ферми приблизительно на 1,0–1,6 эВ. Показано, что при высоких концентрациях примеси, когда сплавы являются двухфазными и состоят из почти чистых Fe, Co или Cr и твердого раствора на медной основе с содержанием Cu приблизительно 95 %, экспериментальные спектры оптической проводимости $\sigma(h\nu)$ сплавов формируются в результате суперпозиции спектров Fe, Co или Cr и указанного твердого раствора с соответствующими весовыми коэффициентами.

Among all 3*d* transition metals, only Ni is well soluble in copper under formation of continuous series of solid solutions with fcc lattice [1]. Other transition metals, e.g., Fe, are low soluble, while Co and Cr, according to literature, are almost copper-insoluble [1]. In this case, optical characteristics, such as refraction $n$ and absorption $\chi$ indices, the dielectric permeability $\varepsilon = n^2 - \chi^2$ and optical conductivity $\sigma = n\chi\nu$ (where $\nu$ is the light frequency) must be described by linear functions of impurity concentration [2]. This is due to that, according to [1], the alloys are heterogeneous mixtures of almost pure copper and impurity, thus, the experimental spectra of the mentioned quantities must be formed by superposition of spectra of the mentioned components with the corresponding weight coefficients.

In this work, the optical properties of binary copper alloys with low content of Fe, Co and Cr have been studied within the spectral range where the interband electron transitions play the main part. The results obtained evidence that the limiting solubility of Fe, Co and Cr in copper are substantially higher than it was believed before.

In the case of Cu–Ni solid solutions, a narrow *d*-band in electron spectrum has been revealed which is associated with Ni