less interaction) to decrease the irreducible e-e interaction V^R by about 15% at $r_s = 1$. Fluctuation effects can be discussed to a certain extent along the lines of Aslamov and Larkin[20] and Maki.[21] However, the novel feature of this system is the fact that the electron density also controls the thickness of the inversion layer and the "excess conductivity" resulting from pairing due to thermal effects in the normal phase could in principle be used to monitor the squeezing out of the third dimension as a function of density. Interface roughness and disorder, which become important at larger r_s, and the competition with other broken symmetries (such as Wigner crystallization, which is under much discussion in related 2D systems[22]) will be discussed in a subsequent paper.[17]

In summary, we have demonstrated the possibility of superconducting pairing in MOS devices, highlighting the density dependence of the various coupling mechanisms. The Si(111)-SiO_2 system is the most favorable of the current generation of MOS devices, but the use of other materials, with higher bulk electron-phonon matrix elements, could further enhance the range of temperature and other variables over which superconducting phenomena would be observed. It is hoped that the present investigation might prompt experimental work to complement that on bulk doped semiconductors.

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Depth-Selective Conversion-Electron Mössbauer Spectroscopy

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A high-resolution, electrostatic electron spectrometer combined with a Mössbauer spectrometer has been used to obtain depth-selective ^{57}Fe Mössbauer spectra from the surface region of an iron scatterer by detecting emitted conversion electrons at selected electron energies. Clear experimental evidence of a sharp depth resolution in the Mössbauer spectra is demonstrated for the first time, in accordance with theoretical predictions.

PACS numbers: 76.80.+y, 73.90.+f

In recent years there has been an increasing interest in conversion-electron Mössbauer spectroscopy (CEMS) as a useful, nondestructive technique for studying surface metallurgy, corrosion, or ion-implanted surface layers because of the small penetration depth of low-energy electrons in matter.[1] In a modification of CEMS, known as "depth-selective" or energy-differential CEMS, one detects the electrons emerging from the solid surface by means of an electron spectrometer.[2] Thus Mössbauer scattering spectra are obtained at different electron energies, unlike conventional (energy-integral) CEMS. In this way information on the depth dependence of physical parameters can be obtained, because monoenergetic conversion electrons are emitted after deexcitation of Mössbauer nuclei (e.g., 7.3-keV electrons in case of ^{57}Fe), and their energy loss is related to the escape depth below the surface of the Mössbauer scatterer.[2,3]

In this communication we demonstrate that spatially resolved ^{57}Fe Mössbauer spectra are obtained if scattered conversion electrons in the energy range between 6.6 and 7.3 keV are detected with sufficiently high energy resolution. Earlier attempts using magnetic electron spectrometers already gave some indication that depth-selective Mössbauer spectra are feasible[4,5]; however, a depth resolution as sharp as in our experiment never has been observed before.

Various electrostatic electron-energy analyzers for CEMS studies have been constructed recently.[6-10] For our experiments we have used a modified commercial electrostatic (150° spherical sector) electron analyzer with a Channeltron detector which usually is employed in photoelectron spectroscopy. The geometry of our experimental setup consisting of a $\sim$40-mCi ^{57}Co Mössbauer source, Mössbauer scatterer (sample) and electron analyzer (all located within an UHV chamber) has been described in some detail elsewhere.[11] The solid angle of the analyzer entrance aperture as seen from the sample center is $\sim$0.27% of 4π, and the detected electrons leave the sample essentially parallel to its surface normal. The angle between the incident 14.4-keV γ radiation and the sample normal was about 62°. If a ^{57}Co source was put in place of the sample the electron spectrum of this source (measured with an energy resolution $\Delta E/E$ of 2%) clearly indicated the K–conversion-electron peak at 7.2 keV and KLM, KLL, and LXY Auger peaks of Fe at 6.2, 5.4, and $\sim$0.6 keV, respectively.[11]

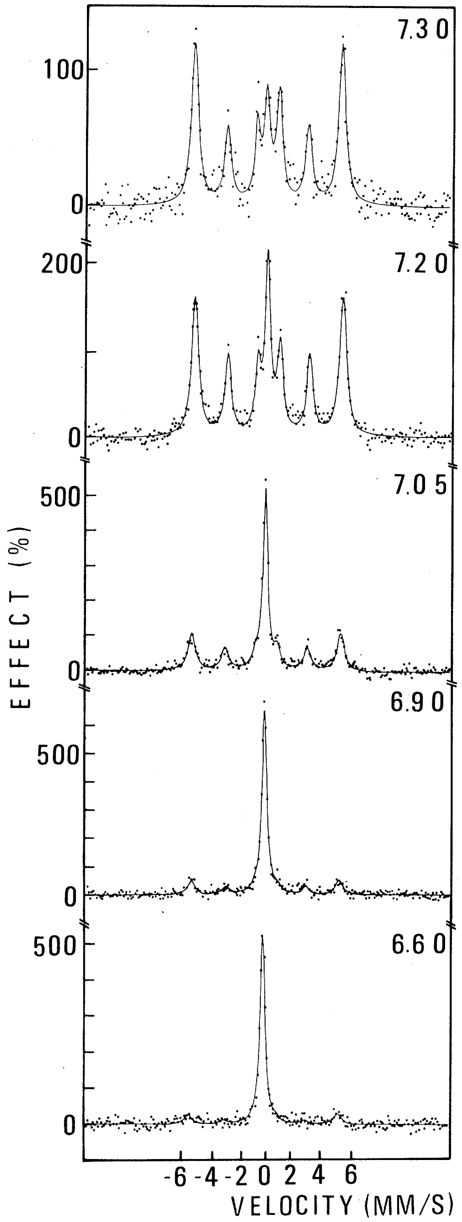

FIG. 1. ^{57}Fe conversion-electron spectra of a 250-Å iron film (95% enriched) vacuum deposited onto a stainless-steel foil (91% enriched) for 7.3-, 7.2-, 7.05-, 6.9-, and 6.6 keV electron-energy setting (from top to bottom). Electron energy resolution $\Delta E/E$ is 2%.

In order to investigate the depth selectivity of energy-differential CEMS, we have made measurements on a layered sample consisting of a (250 ± 10)-Å-thick ^{57}Fe film (95% enriched) which was vacuum deposited onto a (91% enriched) 310 stainless-steel foil (1 mg ^{57}Fe/cm^2). Figure 1 shows the measured Mössbauer-scattering spectra for electron energy settings of 7.3, 7.2, 7.05, 6.9, and 6.6 keV, respectively (from top to bottom), obtained with an electron energy resolution $\Delta E/E$ of 2%. Clear experimental evidence for depth selectivity is found from these spectra. Thus the typical six-line α-Fe signal from the 250-Å iron film is clearly enhanced relative to the central stainless-steel peak of the substrate if electrons of the highest energy (7.3 keV) are selected, since the elastic mean free path of roughly 100 Å for 7.3-keV electrons is of the same order of magnitude as our α-Fe film thickness.[12] Decreasing the electron energy setting reduces the α-Fe overlayer signal and enhances the stainless-steel peak intensity, since these electrons have experienced energy losses and thus originate from regions deeper below the surface; for example, at 6.6-keV electron-energy setting the stainless-steel Mössbauer line is clearly dominating and the α-Fe pattern is hardly detectable in Fig. 1.

A computer analysis of our spectra yielded the relative spectral areas of the thin-film signal (A_s) and of the stainless-steel (substrate) signal (A_{ss}) for each Mössbauer spectrum of Fig. 1. The least-squares-fitted curves (full lines, Fig. 1) were obtained as a superposition of a single line due to the stainless-steel substrate and of a six-line pattern caused by the α-Fe film; in order to obtain a good fit we had to assume, in addition, a weak quadrupole-split spectrum (quadrupole splitting 0.87 mm/s and isomer shift +0.31 mm/s relative to α-Fe) due to an iron oxide phase. Such a very thin (trivalent) iron oxide layer on top of the α-Fe film had to be expected,[13] since our sample was exposed to air for several minutes prior to the CEMS measurements. The spectral area of this thin-oxide spectrum amounted to only ~15% of the α-Fe intensity, however.

In ^{57}Fe CEMS computations always pure iron is considered as scattering material.[3,13-16] Therefore, since the density of Fe atoms is a factor 1.5 higher in iron than in stainless steel, and since the f factors are about equal in both materials, our measured spectral area of stainless steel was increased by a factor of 1.5. The results of this analysis are shown in Fig. 2 where the relative spectral area of the surface layer (α-Fe film plus iron oxide), normalized to the "corrected" total area, i.e., $A_s/(A_s+1.5A_{ss})$, is plotted versus the corresponding electron-energy setting (full circles in Fig. 2).

It can be seen, for example, that 91% of the 7.3-keV electrons (which did not experience an energy loss) originate from a 250-Å-deep surface region. On the other hand, the majority of 6.6-keV electrons (89%) comes from a depth larger than 250 Å, and only 11% originate from the 250-Å thin-film region. Thus the method is very useful for discriminating the information of about 0–250-Å-thick surface layers from that of 250 Å depth inward, if electron energy settings of 7.3 and 6.6 keV, respectively, are chosen at 2% energy resolution.

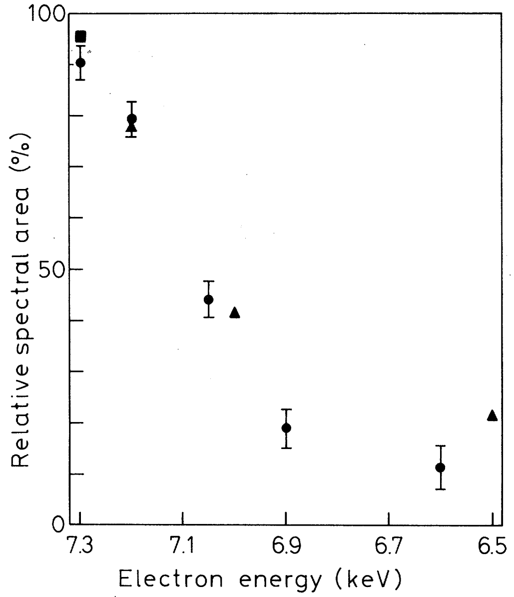

FIG. 2. Relative spectral area (intensity) of 250-Å ^{57}Fe on stainless steel. Circles, corrected experimental values, $A_s/(A_s+1.5A_{ss})$; triangles, theoretical values obtained from Ref. 3; square, theoretical value according to Ref. 15.

Our results can be compared with theory. In Fig. 5 of Ref. 3 the computed probability is given that an emerging electron of measured energy E_K (for 2% energy resolution) originated at a certain depth z below the surface. This probability is based on Fermi age/diffusion theory. If we choose the curve given in Ref. 3 for $E_K = 7.2$ keV and $z = 250$ Å, graphical integration yields a value of about 78% for the fraction of 7.2-keV electrons which originate in this 250-Å-thick surface layer. This value, together with those obtained by the same procedure for $E_K = 7.0$ and 6.5 keV, agree with our corresponding experimental points. In Refs. 14 and 15 the emission into various angular and energy intervals of electrons from different depths has been calculated by the Monte Carlo technique. Unfortunately, this computation has not been given for electron detection within the acceptance angle of our spectrometer but for larger angles relative to the sample surface normal. By using the calculated curves in Fig. 1 of Ref. 15, we find nevertheless that a theoretical fraction of 93% of all 7.3-keV electrons originates from our 250-Å-thick overlayer which also is in good agreement with our corresponding experimental point. Thus the angular dependence of electron emission does not seem to be as important at 7.3 keV electron energy as compared to lower energies where our experimental data points are lower than the values computed from Ref. 15 (not shown in Fig. 2).

Summarizing, we say that our experiments verified for the first time that depth-selective ^{57}Fe conversion-electron Mössbauer spectra can be obtained with a spatial resolution which is in agreement with existing theoretical predictions.

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Solitons in Polyacetylene: Effects of Dilute Doping on Optical Absorption Spectra

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A joint theoretical and experimental study of the effects of dilute doping on the optical absorption spectra of *trans*-polyacetylene, *trans*-$(\mathrm{CH})_x$, is presented. It is shown that the optical transition between a band state and the soliton level is considerably enhanced. However, the existence of a soliton kink strongly suppresses the interband transition. The agreement between theory and experiment supports the applicability of the soliton model to *trans*-$(\mathrm{CH})_x$.

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Interest in the study of the physics of polyacetylene, $(\mathrm{CH})_x$, has focused on the proposal[1,2] that neutral and charged amplitude solitons dominate the magnetic, electrical, and optical properties. The soliton picture has received increasing experimental support through analysis of the magnetic,[3-6] infrared,[7,8] transport,[9,10] and phototransport[11] properties of lightly doped samples. Tomkiewicz *et al.*[12] have asserted, however, that the soliton domain walls do not exist and that the properties of doped $(\mathrm{CH})_x$ are determined by an inhomogeneous mixture of metallic islands in undoped $(\mathrm{CH})_x$.

In this paper we examine the effects of soliton doping on the optical absorption spectra. Calculations of the absorption coefficient (α) show that a soliton kink on a chain suppresses the interband transition, whereas transitions involving the