

Contents

I. Old Materials 1

- | | |
|---|---|
| 1. General Classifications | 1 |
| 2. Lattice Instabilities in Elements, Binaries and Pseudobinaries | 2 |

II. Old Theory 26

- | | |
|---|----|
| 1. Electron-Ion and Electron Phonon-Interactions in Simple Metals | 26 |
| 2. Simple Models | 31 |
| 3. Transition Metals and Their Compounds | 37 |
| 4. Solving the Gap Equation | 44 |
| 5. Normal-State Properties | 51 |

III. New Materials 60

1. Chevrel Phases 60
2. Perovskite Superconductivity 66
3. Copper Oxides 74
4. Quaternary Copper Oxides 85
5. Oxygen Vacancy Ordering in $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ 92
6. Copper and Other Cation Replacements 96
7. Normal-State Transport Properties 100
8. Pressure Effects 108
9. Metallic (But Not Superconducting) Copper Oxide Pseudoperovskites 110

IV. New Theory 118

1. Aims and Scope 118
2. Electronic Structure of $\text{BaPb}_{1-x}\text{Bi}_x\text{O}_3$ 120
3. Formal Valence in the Cuprates 125
4. One-Electron Structures of La_2CuO_4 and $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$. 126
5. Semiconductivity and Antiferromagnetism in La_2CuO_4 and $\text{YBa}_2\text{Cu}_3\text{O}_6$ 132
6. Electron-Phonon Interactions in $(\text{La}, \text{M})_2\text{CuO}_4$ and $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Alloys 138
7. Defect Electronic Structure 148
8. Localization and Marginal Dimensionality 150
9. Normal-State Properties 154
10. Defect-Enhanced Electron-Phonon Interactions 161
11. Coupling Constants and Gap Anisotropy 166
12. Exotic Theories and Ultimate Causes 168
13. Selective Phonon Condensation 175

V. Isotope Effect 185

1. Old Materials 185
2. Cuprates 187
3. Fictive Phonons and the Isotope Effect 188
4. Lattice Instabilities and Anharmonicity 190

5. Physical Implications of Isotope Shifts	192
 VI. Lattice Vibrations 196	
1. Metallic, Covalent and Ionic Forces	196
2. Lattice Instabilities and Phonon Spectra	201
3. Infrared and Raman Lattice Vibration Spectra	207
4. Sound Velocities, Internal Friction and Lattice Instabilities	221
 VII. Optical Spectra 228	
1. Samples and Surface Preparation	228
2. Composite Reflectance Data	230
3. Single crystal YBCO Reflectivities	232
 VIII. Tunneling 238	
1. Point Contacts and Dead Layers	238
2. Break Junctions	242
3. Gap Anisotropy of Epitaxial Thin Films	243
4. Physical Model of Cuprate Junctions	248
 IX. Relaxation Studies 251	
1. Sound Velocity and Attenuation	251
2. Cu NMR Relaxation Rates in YBCO	254
 X. Materials Morphology 261	
1. Intergranular Weak Links	261
2. Epitaxial Films	262
3. Single Crystals	264
4. Critical Field Anisotropy and Macroscopic Parameters	268
5. Meissner Effect and Type III Superconductivity	272
6. Twin Boundaries and Giant Flux Creep	278

7. Microscopic Inhomogeneities	285
XI. Bismates and Thallates	293

Appendices

A. Macroscopic Parametric Relations	305
B. Microscopic Theory	308
C. Crystal Chemistry	316
First Author Index	380
Subject Index	385