11/10/15
Engineering
Physics
Color Center in Alkali Halides Symposium
Oct. 11-13, 1965

The four reels of tape are recorded at 3 3/4 speed on a dual track stereo recorder so that the four voice tracks are on each reel of tape.

The following index is keyed to the review papers and the slides presented by each speaker. The complete abstract of the review papers appears in the printed program.

Reel 1 - Track 1

0-45 Empty
46- Theory of Optical Transitions in the Electron-Excess Centers by W. Beall Fowler (University of Illinois)
Discussion of lattice states
120- Computation of electronic properties
145- Criteria
1- position of the nuclei
2- proper consideration of electronic polarization
3- Pauli principle and ionic potentials
170- F centers and U centers are neutral centers
185- F centers are easiest to calculate.
Wave functions in absorption
223- Computation of energies and wave function of the F center
1- Common point - ion potential
Slide 1
260- Extended ion potential
274- 2- Semi-continuum potential of Simpson Slide 2
300- Constant energy
330- Comparison of models 1 and 2
1 is better for F band energy calculation Slides 3, 4 & 5
370- Higher excited states of the F center
397- Calculation of K band of F center
425- F center in emission
Lifetime of excited F center Slide 6
Slide 7
Slide 8
495- Relaxed states on conduction bands Slide 9
528 3 distinct states of the F center band
1- tightly bound state - no polarization
2- K-band region - semi-continuum states characterized by a high frequency dielectric constant.
3- static dielectric constant with more diffuse excited states.

540- M centers Slide 10
592- M center in emission
605- R center analog of the H3 molecule
619- F' Band " " " negatively charged hydrogen atom in a crystal
Slide 11
650- Progress in understanding centers
650- (Cont) Need for detailed calculations

Reel 1 - Track 2

The Calculation of the Electronic Structure of Lattice Defects in Ionic Crystals by R. F. Wood (Oak Ridge National Laboratory)

0-7 Introductory Remarks
8- Calculations of electronic structure Slide 1
Slide 2
50- Polarization Slides 3 & 4
Methods of calculating orthogonization
110
185 Localized states
188 end

Reel 1 - Track 3

0 "Creation of Defects in Alkali Halides by Ionizing Radiation" by J. H. Crawford, Jr.
Since 1959, it has been accepted that interstitials as well as vacancies were created by ionizing radiation.
70 Varley mechanism
95 Kinetic energy
Results of studies of mechanisms for radiolysis
180 Klick and Patterson studies
200 Conflict between theory and results
210 Interstitial halogens and the form in which they exist in the crystal. Room temperature experiments.
Nadeau and Suzuka experiments with F centers
240 Slide 8
248 Slide 9
260 Absorbtion F centers - Bleaching time Slide 10
273 Effect of bleaching on flow stress of irradiated KCl Slide 11
306 Slide 12
315 Slide 13
320 Slide 14

363 Effect of adding impurities Slide 15
385 We know more about the quantitative aspects than in 1962.
The mechanism still remains to be established. Interstitials exist at room temperature - irradiation, but the form in which they exist is unknown.
Radiolytic processes at room temperature
400 One creation mechanism is needed.
Black reaction is responsible for differences

Reel 1 - Track 4

7- F- Aggregate Centers in Alkali Halide Crystals by Herbert Rabin (U.S. Naval Research Laboratory)>
10 This review is facilitated by a recent survey article written with W. D. Compton.
15 Three areas Slide 1
1- Experimental Evidence for Models
2- Processes of Formation and Destruction
3- Theory & Studies Relating to Excited States
36- Experimental Evidence for Models Slide 3
A- Electric properties - None found
B- Magnetic properties - Siedel will discuss this. F2 & F3 Models.
56- C- Optical properties -
65- Unpolarized bleaching

M. Veda was the first to use polarized light in examination of the M center.
97- M. centers - evaluation of optical studies.
120 A Quadratic relation between F and M centers can be expected Slide 5
126- KCl Slide 6
142- Slide 7
150- Slide 8
162 KCl Slide 9
168- Slide 10
176- II Processes of Formation and Destruction Slide 11
A. Ionizing Radiation
185- 1. Low Temperature Slide 12
213 2. Room Temperature Slide 13
232 B. Optical Conversion
237 1. F>M Conversion
243 NaFl sensitive to temperature Slide 14
Luty
2. Temporary Products see Siedel
273 3. Ionized Centers Veta
300 Slide 15

314 C. Thermal Treatment
319 1. Dissociation Slide 16
324 Slide 17
338 2. Generation Slide 18
348 III Theory & Studies Relating to Excited States Slide 19
A. M - Center Theory S. Wang
381 B. First Excited State
398 Slide 21
415 C. Higher Excited States Okamoto, Susman
432 Optical Studies cover the F - aggregates
F2 & F3 models of the M & R centers are established.
M1 & M2 centers require further work.
Mechanisms of optically exciting the centers need study.
461 F-aggregate centers in other alkali halides may not perform like KCl
Additional bands may appear.
478 End

Reel 21 - Track 1

"Influence of the Host Lattice on Color Centers" by Franco Bassani
(Argonne Laboratory and University of Messina)
Electronic Effects on centers
7- Three Effects on Centers
10- 1st
75- 2nd
133- Spin orbit - splitting
ground state - excited state transitions
(Many calculations are described as they are written on the chalkboard.)
250 State 4 -A- 2 Slides
262 Three bands in the cesium halides
Frequency survey references to the work of others in the field.
symmetry
splitting of degeneracies.
349- Third determination of the position of the energy that is in the
color center.
calculation of excitation spectra
Work of F. Luty
409 K Band L Band
435 Excitation states about the continuum
470 Scattering theory shows resonance states in the continuum.
520 Density of states in the continuum.
525 Slide L
570 Kojima
606 Resonance states

644 Shape of absorbtion band
685 Theoretical Understanding of the L Band
688 End
690-712 Question
713-732 Lins Shape
733-805 Question - L Bands
806-837 polarization energy
838-911 2 questions, excitations - polarization - conduction bands

Reel 2 - Track 2

"Anionic Impurities in Alkali Halide Crystals" by J. Rolfe (National Research Council of Canada)

60 papers have been written on this topic since Stuttgart (1962).
28 Classifications of Anionic Impurities Slide 1
soluble impurities
82-110 partially soluble, adventitious impurities
111-117 insoluble or slightly soluble impurities
118 Location of dipolar anionic impurities
opening a large new field
150 Expected ionic activity
153 Dr. Rolfe's research on conductivity to measure impurities Slide 2
172 Slide 3
190 Slide 4
206 Slide 5
Doping with divalent anionic impurities have not produced alkali halides results similar to silver halides.
230 End

Reel 2 - Track 2

"Rare Earth Impurities in the Alkali Halides" by Walter E. Bron (IBM)

260- Start
280- Slide?
295 Slide?
crystal field - knowledge of the lattice field
312 Slide 3
340 Effects of lattice motion
354 Slide 4
Group Theory
400 Strong electron lattice couplings
433 Slide?

450 KBr spectrum
Electron lattice coupling
470 End

Reel 2 - Track 3

"Production of Ultrapure Alkali Halides - A Survey" by C. T. Butler
(Oak Ridge National Laboratory)

1- We use KCl. Others use KBr
We want clean crystals

Zone refining
Techniques
1 - sublimation (Anderson) inferior method
40- 2 - ion exchange (Fredericks)
3 - zoning
4 - chemistry
52 Chemical purification Slide 1
72 Fusion - filtration tube
83 Slide 2
134 Clean your furnace
keep your laboratory clean
clean rooms cost $200 a sq. ft.
150 Vacuum tight furnace
153 Slide 3
180 Slide 4
206 Slide 5
Need information on physical purity - NaCL
Need literature on purity. Lack of literature on best purification or growth techniques.
245 End.

Reel 2 - Track 4

"Trapped Hole Centers in the Alkali Halides" by Charles J. Delbecq
(Argonne National Laboratory)

1-
17- Vk (x2) center model Slide 1
31- ultraviolet and red Slide 2
55 spin orbit interaction
87- C12 ions in the alkali chlorides Slide 3
130 trapping of holes - Vk center is the primary configuration.

135	Hole centers which involve an impurity	
142	H center - Kanzig	
147-193	Review of five models	Slide 1
225-230	Stabilization of Vk centers	
235-245	V centers	
260-300	F & Cl- centers in KCl. interstitials	Slide 4
312	V1 centers	
382	Electron - Hole Recombination Luminescence (Kabler, Wakita, Veta Murray and Keller)	Slide 5
420	Electron - Hole Recombination Luminescence (Yuster, Delbeq, Ghosh, Timusk and Martienssen)	Slide 6
475	tunneling probabilities	Slide 7
495	End.	

Reel 3 - Track 1

"Color Centers in Magnesium Oxide" by John E. Wertz (Minnesota)

7-	Start impurities	
36	Spectra for F centers in MgO references to articles	Slide 1
104		Slide 2
114		Slide 3
120		Slide 4
141	Trapped hole centers Models proposed by Seitz	
170		Slide 5
185		Slide 6
203		Slide 7
205		Slide 8
222		Slide 9
238		Slide 10
250	thermoluminescence	
260		5 slides
278		Slide 16
301	Charge release experiments	Slide 17

Similarities and differences with respect to alkali halides.
Differences due to divalent positive and divalent negative ion lattice.

318 End.

Reel 3 - Track 2

"Influence of External Perturbations on Optical Transitions in Electron Excess

Centers" by Charles P. Slichter (University of Illinois)

1-
Work on the R center external perturbations have enabled us to spin-orbit splitting
20 Degeneracy creates two main problems
1 - Adiabatic approximation
2 - Dilemma of quantization(87)
40 List of workers in areas covered by this paper Slide 1
55 Henry & Schnatterly did most of this work
89 Slide 2
120 spin-orbit splitting
160 Slide 3
240 quenching orbital angular momentum Slide 4
284 Slide 5
378 Slide 6
415 Slide 7
421 Energies in the Slide 8
450 Work by P. R. Moran

Slide
Conclusion from examination of Optical Absorbtion lines
493 End.

Reel 3 - Track 3

"Color Centers in Alkaline Earth Fluorides" by A. Smakula (Crystal Physics Laboratory, M.I.T.)

3-
50 We have studies CaF2, but not Sr F2 and BaF2
Potassium, copper and similar
72 Impurities not dangerous in study of color centers.
77 More dangerous are oxygen in hydrogen
100 CaF2 Vienna experiments
106 Gottingen improved experiments
112 Slide 2
135 Absorption of crystals additively colored Slide 3
188 X-rays. Ultraviolet absorption of colored fluoride crystals Slide 4
217 Influence of impurities on the position of color center bands, absorption coefficients for pure and oxygen contaminated crystals
Slide 5
290 Doping with Yttrium Fluoride analysis of bands Slide 6
310 Doping with NaF analysis of bands Slide 7
337 Doping at low temperature Slide 8

350 " " " " Slide 9
357 Slide 10
366 Slide 11
Absorption bands, spectra
Far behind alkali halides
388 End.

Reel 3 - Track 4

"Summary and Concluding Remarks" by H. Pick (Physikalisches Institute, Universitat Gottingen)

17 I attended 1956 conference
we have reached peaks in this flat country
35 Survey talks have helped
40 Papers covered:
color centers and hole centers in pure, mixed and doped crystals. Aggregate centers and impurity centers with many difference foreign cations, anions, and mutual atoms.

Theory of optical transitions of zero phonon lines.

45 Techniques and methods
High Energy
Resonance
54 Three impressions
1 - Concern with number of papers presented
2 - Color center physics is a basic part of solid state physics
3 - Youthful workers
74 Important advances in work on the F center
85 L Band theory in a preliminary stage
96 Zero phonon lines are an excellent means for the control of symmetry parameters and study of the couplings between electronic and vibrational sites.
122- F aggregate centers
146- Need experimental methods controlling radiation effects
150- Vibration effects.
Infra-red work
165 Impurities and better crystals
174 Broader concept of a dynamic theory
178 Shift from alkali halides to other materials, particularly those of higher technical applicability.
184 Study of ordering forces
203 End.

Reel 4

0-26 Introductory Remarks by R. J. Maurer

27- Historical Background of the Work on Color Centers by R. Hilsch (Physikalisches Institut der Universitat Gottingen)

1925 - Student from Stuttgart to Gottingen to work with Prof. R. W. Pohl. Now 81, Pohl retired 10 years ago.

48- photoconductivity on diamonds
Diamond was destroyed
Alkali halides were used
measure bands
A. Smakula worked on the measurements.
Atomic physics and quantum physics were popular
Our solid state research was isolated. Having nothing to do with atomic theory, it was scarcely noticed.

90- We developed the techniques for the investigation of alkali halides.
We used vacuum photoelectric cells with sodium for the ultraviolet.
measurement techniques

Growth crystals. Optical equipment

110- Discoloration notices. "F centers" or "color centers" first used in 1930.

120- Impurities
spin resonance
Al Gottingen work was done to study the alkali halides to apply acquired knowledge to other substances.
It has benefitted solid state physics and semi-conductor work.
1930 - Baurer. Light reflection reduced by KBr coating.
Smakula - developed this at Zeiss
1932 - F centers in alkali halide crystals migrate at high temperatures. Electrolytic discoloration. Problems remain here.

145- 1938 - Controlled migration of F centers
Solid state amplifier proved practical. No technical device developed.
1948 - three electrode Germanium crystals or transistor

150-
Pohl - preferred facts to theories
1946 - F. Seitz review article on Gottingen work.
They lacked interest in theories
Experiments were what was needed to furnish interpretations.

175- Great number of papers at this meeting
Problem to organize knowledge of our field.
Thank program committee

205- Abstracts

10/10/15 11

206-210 Maurer concluding remarks.

Previous conferences:

1956 - Argonne	1962 - Stuttgart
1959 - Corvallis	1965 - Urbana