Materials Science Education at KEIO University: Adopting U.S. Instruction Practices in Japan

Kohei M. Itoh

Dept. Applied Physics and Physico-Informatics,
Keio University

2002 MRS Fall Meeting

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2. Introductory Materials Science course for 1st year students
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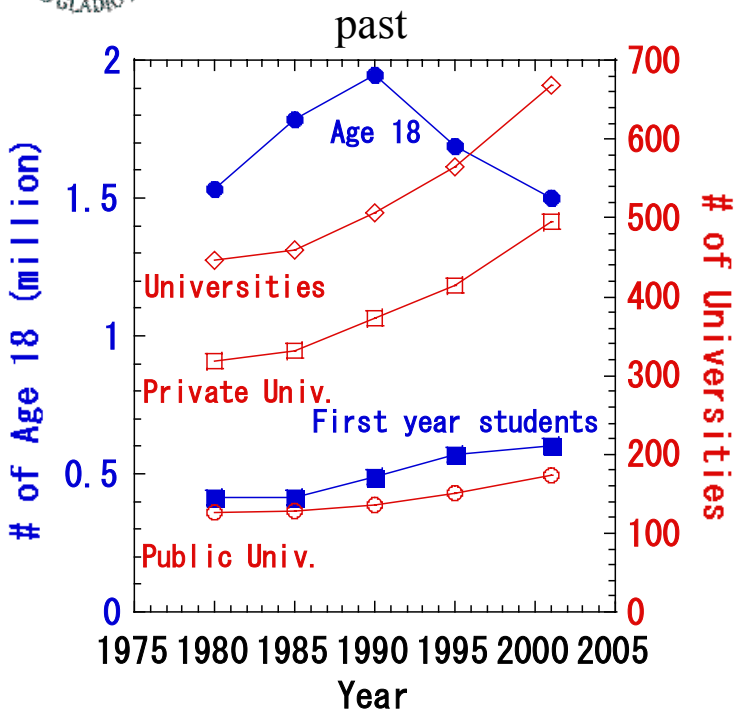
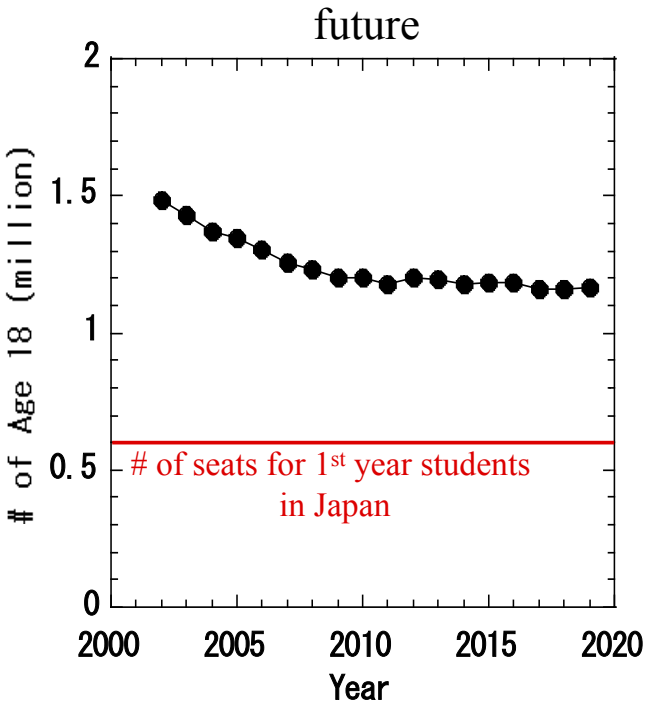
Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
Keio University

Number of universities and population of age 18 in Japan





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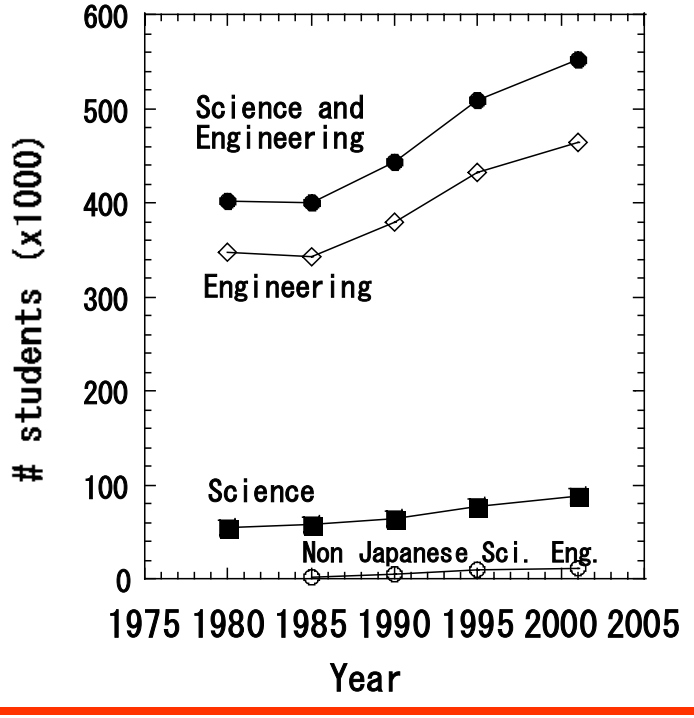
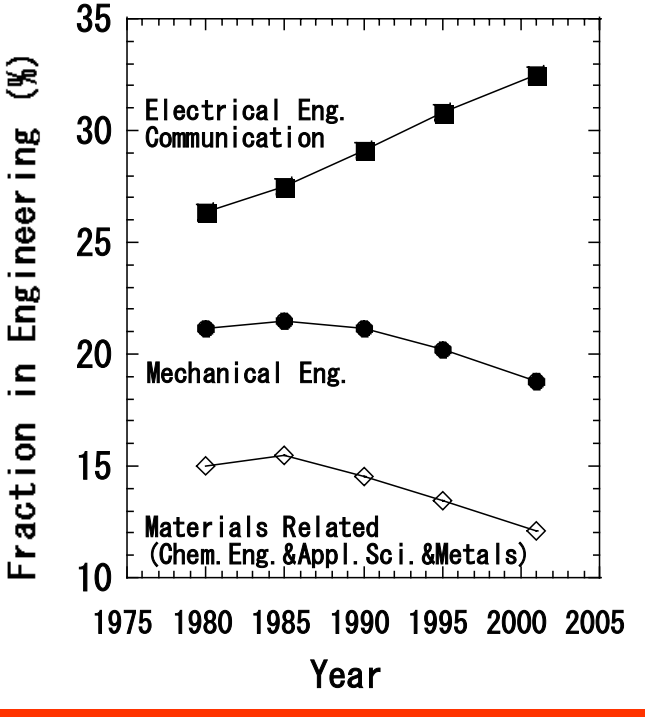
Trend in Science and Engineering





Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
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Keio University

Founder: Yukichi Fukuzawa
Established in 1858 (oldest priv. university)
Letters, Economics, Law, Medicine,
Science&Technology, Business&Commerce
Policy Management, Human Relation, etc.

1,500 Full-time faculty members
28,000 Full-time undergraduate students

Currently 6 (out of 22) Ministers of Japan are Keio graduates

Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
Keio University

Science and Engineering at Keio

http://www.st.keio.ac.jp/index-e.htm

250 Full-time faculty members
4500 Full-time undergraduate students
1750 Full-time graduate students (MS&PhD)

11 Departments
Administration Engineering
Applied Chemistry (MSE related)
Applied Physics (MSE related)
Biosciences and Informatics
Chemistry (MSE related)
Electronics and Electrical Eng. (MSE related)
Information and Computer Science
Mathematics
Mechanical Eng. (MSE related)
Physics (MSE related)
System Design Engineering

Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
Keio University

1st year at Keio Sci. & Technology

Course 1: Physics related

1. **Physics**
2. **Applied Physics**
3. **Electronics and Electrical Eng.**
4. **Mechanical Engineering**

Course 2: Math related

1. Mathematics
2. Administration Engineering
3. Information and Computer Science

Course 3: Chemistry related

1. Chemistry
2. Applied Chemistry
3. Applied Physics
4. Bioscience and Informatics

Course 4: Mechanics related

1. **Mechanical Engineering**
2. System Design Engineering
3. Administration Engineering
4. Applied Chemistry

Course 5: Information Related

1. Information and Computer Science
2. **Electronics and Electrical Eng.**
3. System Design Engineering
4. Bioscience and Informatics

Each student belongs to one department from the 2nd year

Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
Keio University

Introduction to Materials Science

Freshmen in Course 1-5, 150 enrollments

Chapter 1: Crystal Structures&Defects
Chapter 2: Thermodynamics and Kinetics
Chapter 3: Materials Science of Japanese Katana (sword)
Chapter 4: Ceramics
Chapter 5: Electronic Materials
Chapter 6: Magnetic Materials

Promote students' interest in Materials Science !

Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
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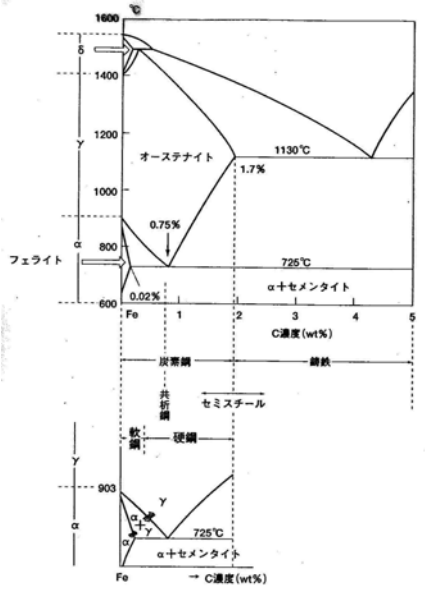
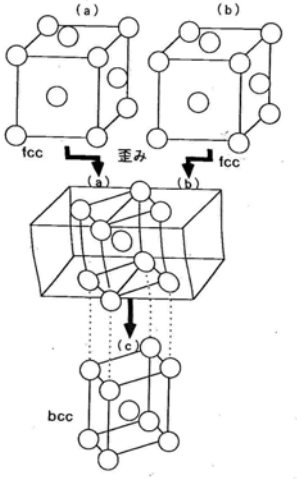
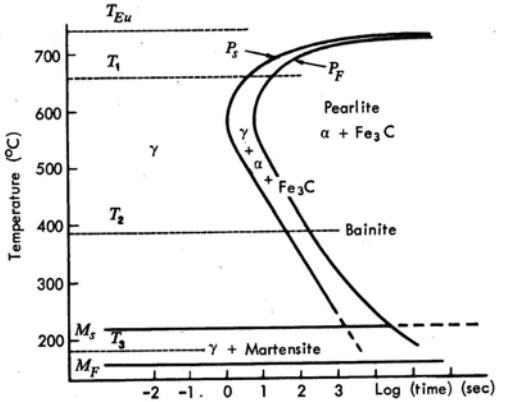
Introduction to Materials Science



Fe-C 二元系状態図



マルテンサイト変態（三島良績編『100 万人の金属学（材料編）』アグネ，1965 より）



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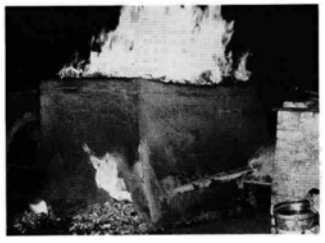
Keio University

Introduction to Materials Science



操業３日目の炉の状態.

水減しされた玉鋼.

炉を崩して精鋼（鋼）をとりだす.

テコ台（テコ皿）を付ける.

鋼出し作業.

沸かされた鋼を大槌で叩く.

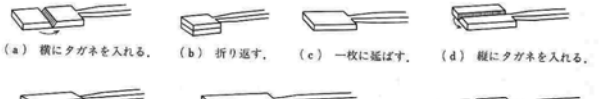
① 折り返しのため，タガネを入れる.

② 折り返される鋼.

③ 折り返しされた鋼.

④ 折り返し鍛錬された鋼の断面.

折り返し鍛錬

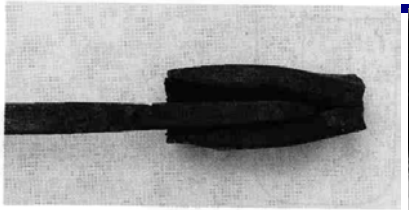


（a） 横にタガネを入れる.　（b） 折り返す.　（c） 一枚に延ばす.　（d） 縦にタガネを入れる.

（e） 折り返す.　（f） 一枚に延ばす.　（g） 横にタガネを入れる.

十文字鍛え

Introduction to Materials Science

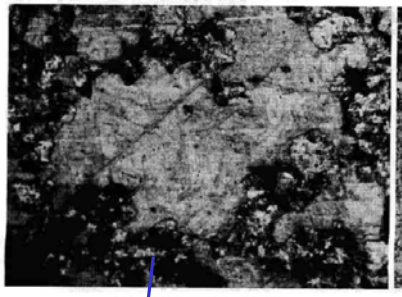


心鉄を皮鉄で包む.

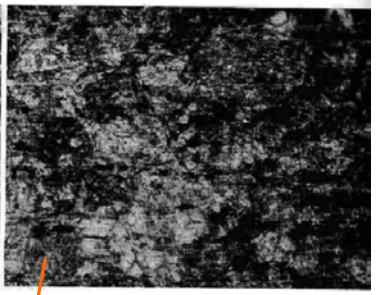
素延べ

合いをとる.

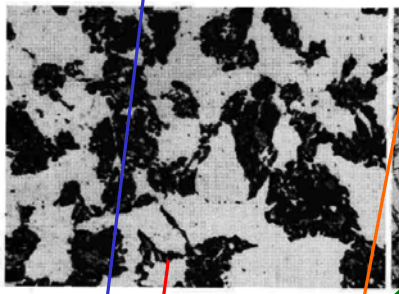
焼き入れ



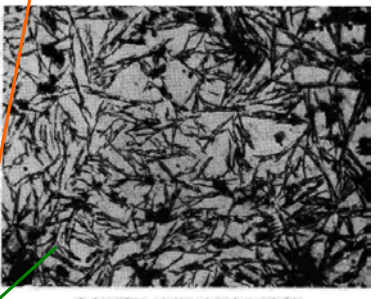
忠広の断面（刃文部の組織）.



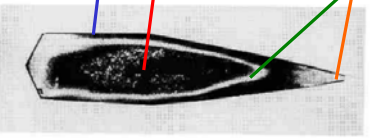
忠広の断面（刃部の組織）.



忠広の断面（棟部の組織）.



忠広の断面（心部刃文部寄りの組織）.



忠広の断面組織.

刃文部ミクロ組織：マルテンサイト＋トルースタイト

刃部ミクロ組織：微細マルテンサイト

心部ミクロ組織：ソルバイト＋フェ

Materials Science Program at Dept. Applied Physics and Physico-Informatics

Double major in Electrical Engineering and Physics (120/class)

2nd year: Electricity and Magnetism, Engineering Math, Electronic Circuits, Programming, Logic Circuits, Quantum Physics, Thermal Physics, Labs

3rd year: Control Engineering, Advanced Electronic Circuits, Signal Processing, Sensing Engineering, Math, Advanced Quantum Mechanics, Statistical Physics, Materials Science, Solid-State Physics, Photonics, Semiconductor Devices, Magnetics, Optical Fibers, Inorganic Electronics, Labs

4th year: Senior Research

Requirements in Red

Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
Keio University

Challenges

Japanese University Traditions

- Strict control of the Ministry of Education
- Once a week lecture for every course
- No teaching evaluation by students
- very little homework, same exams
- Strong seniority system
- No office hours
- Little support for teaching assistants (TA)

Solid-State Physics for 3rd year

US teaching style

- Requirement – Every student must take it
- Once a week lecture plus a discussion session by TA for 13 weeks
- Homework every week for 10 weeks
- Take home mid term exams
- Final exams
- Office hours, teaching evaluation
- Mechanical grading (30% HW, 20% ME, 50% FE)

Evaluation by students (after UC Berkeley)

GENERAL RATINGS

Please rank from one (1) to seven (7)

1. Considering both the limitations and possibilities of the subject matter and course, how would you rate the **overall teaching effectiveness** of this instructor?
2. Focusing now on the course content, how **worthwhile was this course** in comparison to others you have taken in this department?

CLASSROOM PRESENTATION

Please rank from one (1) to five (5)

1. Gives lectures that are well organized.
2. Is enthusiastic about the subject matter.
3. Identifies what he/she considers important.
4. Has an interesting style of presentation.
5. Uses visual aids and blackboards effectively.

INTERACTION WITH STUDENTS

Please rank from one (1) to five (5)

1. Encourages questions from students,
2. Is careful and precise in answering questions.
3. Relates to students as individuals.
4. Is accessible to students outside of class.
5. Is friendly and helpful to students during office hours.

ASSIGNMENTS AND EXAMS

Please rank from one (1) to five (5)

1. Gives interesting and stimulating assignments.
2. Gives exams that permit students to show their understanding.
3. Uses a grading system that is clearly defined and equitable.

COURSE

Please rank from one (1) to five (5)

1. Required course material is sufficiently covered in lecture.
2. Pace of the course is too fast.
3. The required text/notes are beneficial.
4. Workload is heavier than for courses of comparable credit.

Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
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Reaction to the US style

1/2 love it, 1/4 think OK, 1/4 hate it.

Students who like it

- **have learned a lot (regardless of final grades)**
- **have found Materials Science very interesting**
- **have started graduate studies in the US**

Students who think OK

- **have found the work overwhelming**
- **have stronger interests in other fields (subjects)**

Students who hate it

- **have not been prepared for so much work**
- **have found it unfair**

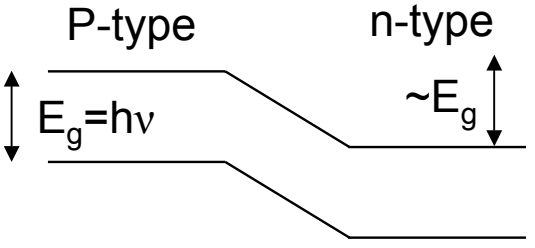
3rd Year Labs

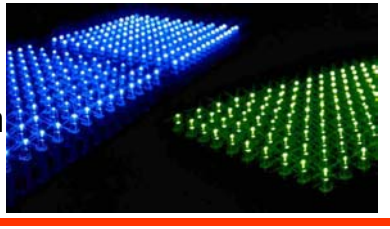
Once a week, 5 hours, for 24 weeks

- **Power Amplifier**
- **Statistical data processing**
- **Brownian motion**
- **Hall effect**
- **Liquid crystal**
- **Light emitting diodes**
- **Logic circuits**
- **Analog computing**
- **Simulation and modeling**
- **Dielectrics and Phase transition**
- **Optical fibers , etc. etc.**

Example: Light emitting diodes (LED)

- **Measure I-V and C-V of Green, Blue, Orange, and Red LEDs**





Red	~1.9 eV
Orange	~2.1 eV
Green	~2.5 eV
Blue	~2.8 eV

Kohei M. Itoh

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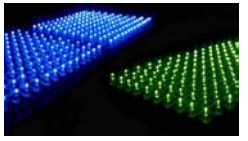
3rd Year LED Experiment



Red	~1.9 eV
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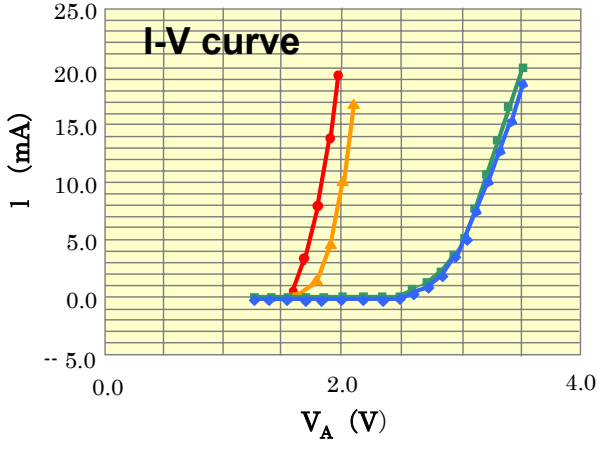
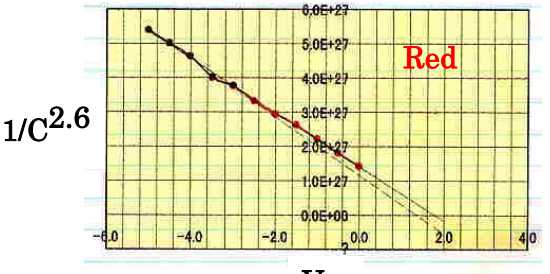
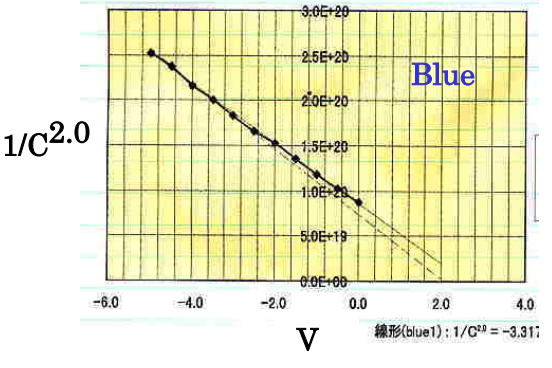


C-V curve



$1/C^3$ for linearly-graded junction



$1/C^2$ for step junctions

Kohei M. Itoh

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Keio University

4rd Year Senior Research

- Every student chooses an advisor and performs research
- Students take less than 3 courses in their 4th year
  Each research group establishes study group
- Unique opportunity to experience what is like to be scientists and engineers
- Experience research proposals, thesis writing, presentation, and possibly publishing journal papers.
- Opportunity for faculty members to evaluate students' ability to perform research

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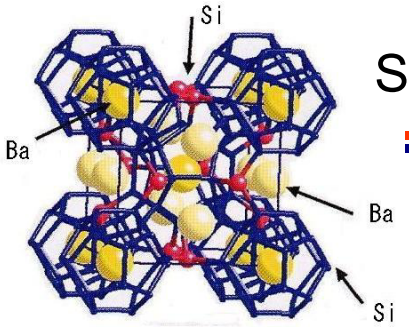
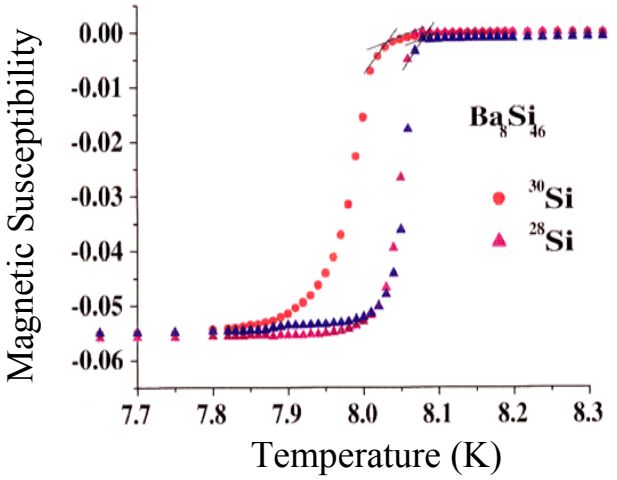
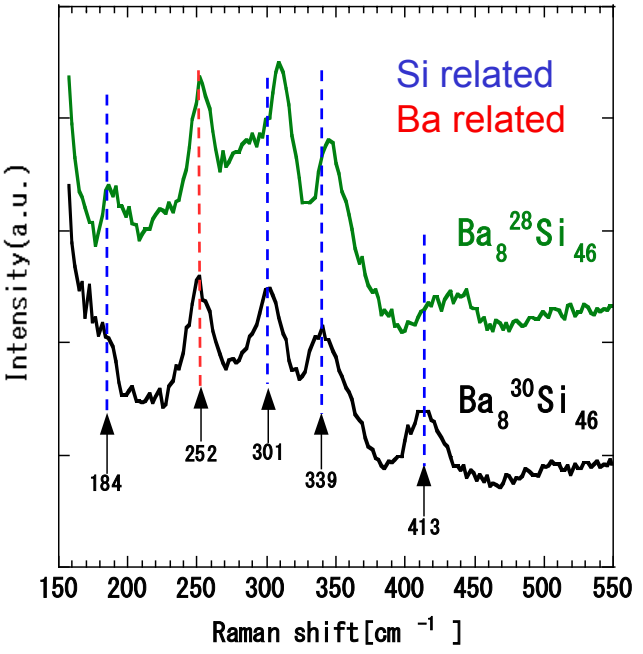
Superconductivity in $Ba_8{}^{28}Si_{46}$ and $Ba_8{}^{30}Si_{46}$





Vibrational spectroscopy by Raman



Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
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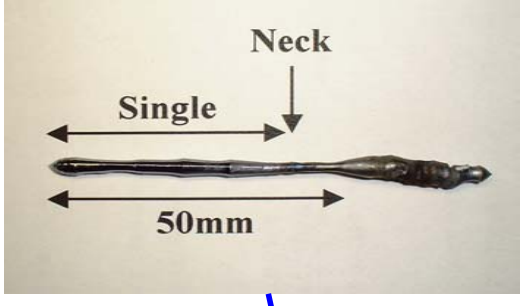
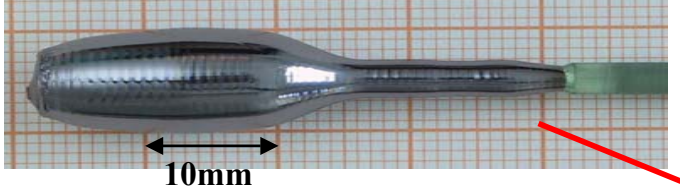
Senior Research Topics at Itoh Group

Molecular Beam Epitaxial (MBE) growth of isotopically engineered low-dimensional silicon structures

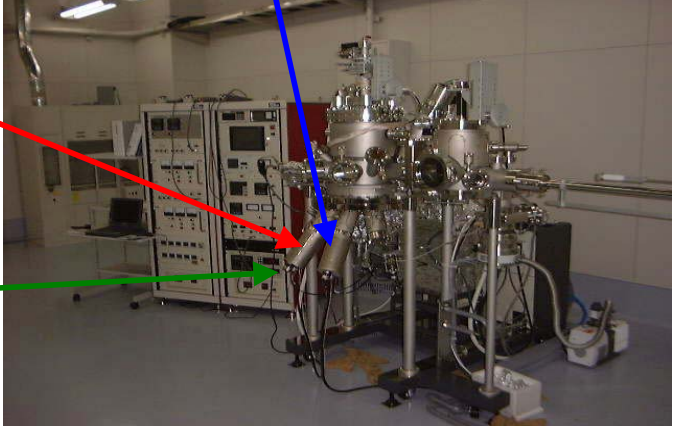
99.92% ^{28}Si single crystal



96% ^{29}Si single crystal



99.3% ^{30}Si single crystal



Summary

- Interest in Engineering is going up but in Materials Science is going down in Japan
- 1st year general Materials Science course is important
- US teaching style has been well received
- Strong emphasis on undergraduate lab courses
- Senior research has been successful
- English-based graduate programs on Nanoscience is starting on Fall 2003. http://www.st.keio.ac.jp/index-e.htm

Kohei M. Itoh

Department of Applied Physics and Physico-Informatics
Keio University