Session 26EP

Superconducting joining of MT- YBCO by Tm123 powder

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An increase in j_c in 1.5-1.6 times through the ring from MT-YBCO soldered by Tm123 powder as compared with that in the singledomained ring was observed up to the 2,5 T field. At 0 T $j_c = 34,4$ kA/cm^2 for the joined sample. The obtained seam was practically invisible under a polarizing microscope; the bending strength of the seam was even higher than that of the material being joined.

High pressure-high temperature treatment of MT- MeBCO (Me=Y, Nd, Sm)

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Using a short-term (15 min) high pressure-high temperature treatment, highly dense MT-MeBCO, Me=Y, Nd and MeBCO-Ag (Me=Y, Sm with additions of Ag) materials with improved SC and mechanical properties can be produced. For the MT-YBCO-Ag (with additions of Ag), after treatment we observed a 1.6-1.8 time increase in j_c in magnetic fields up to 2 T.

26EP3   **Evaluation of Density and Distribution of the Critical Currents in Melt-Processed HTS Bulks with Levitation Force Measurements**

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We have created a set of approaches to calculate the forces acting between an extremely hard bulk superconductor and a permanent magnet. Based on this, a few techniques of critical current determination in bulk melt-processed high temperature superconductors (HTS) have been developed. Using local force measurements we propose an empirical approach to estimate the quality of superconducting joints between blocks of HTS bulks. As a measuring value, we introduce a joint's quality factor and show its natural correlation with joint's critical current density. Being simple and non-destructive, these approaches are considered to be quite important to solve the problem of utilization of HTS in large scale applications.

26EP4   **Non-temperature dependence Resistor at Low Temperatures**

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We measured the temperature dependence of metal film chip resistors (SUSUMU Co.,LTD. RR1220 100Ω, 1KΩ and 10KΩ) from 45mK to 300K. Although the temperature dependence of these resistors R are not monotonic, the changes in resistance $(R(max.) - R(min.))/R(T = 300 \text{ K })$ are within 1%. Therefore, it is easy to design and check a circuit which works at low temperatures. We also introduce our recent experiments on the temperature dependence of 1MΩ resistor and chip mica capacitors.

26EP5   **A replacement for AGOT graphite?**

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Pitch bonded graphites are among the best known thermal insulators at sub-Kelvin temperatures. At higher temperatures, however, they are good conductors. Graphite supports can therefore be used to allow a relatively rapid cool-down of structures which must be thermally isolated when cold. The low temperature conductivity of graphites varies by many orders of magnitude depending on the manufacturing process. AGOT graphite is known to be a very good insulator, but is no longer commercially available. We suggest a replacement, and present thermal conductivity measurements demonstrating its suitability.

Magnetic properties of a conductive epoxy Eccobond23C

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Thermal contact is essential for low temperature experiments. Ge-vanish is usually used as glue to make good thermal contact. However, electronic conduction of glue is necessary to achieve good thermal contact below 10mK. Recently, a conductive epoxy Eccobond 23C is employed to glue a sample at very low temperature experiments and thermal contact of the sample is satisfaction. We report Magnetic properties of an Eccobond 23C at temperatures down to 0.2mK.

Relaxation of Excitons in Uniaxially Stressed Ionic Crystals at 4.2 and 80K

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Using optical absorbtion, luminescence and termoactivation spectroscopy, we study the formation and relaxation processes of electronic excitations in ionic crystals with the lowered lattice symmetry and at 4.2 and 80K. The dependence of the efficiency of radiative relaxation of self-trapped exciton (STE) on the charge and size of point defects is studied. Deriving technology of thin films of alkali iodides is elaborated and the relaxation processes of STE in these films are studied. We have found that the emission efficiency of STE in uniaxially stressed alkali halides and thin films of alkali iodides is noticeably increased. Such an enhancement of the STE (e.g. σ, E_x, π) luminescences is very important for the elaboration of alkali halide scintillators operating in the intrinsic STE emission without energy transfer to the impurities as in classic scintillators NaI-Tl and CsI-Tl.

Sound Velocity of High-strength Polymer with Negative Thermal Expansion Coefficient

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Sound velocities of the fiber-reinforced plastics were measured along the fiber axis at temperatures between 360K and 77K. We used two kinds of the high-strength crystalline polymer fibers, polybenzobisoxazole (Zylon) and polyethylene (Dyneema), which have negative thermal expansion coefficients. They also have high thermal conductivities and high resistances for flash over voltage, and are expected as new materials for coil bobbins or spacers at cryogenic temperatures. They have very large sound velosities of about 9000 (m/s) at 77K, which are 4.5 times larger than that of the ordinary polyethylene fiber.

26EP9   **Cyclotron resonance in the layer compound InSe-the lower magnetopolaron branch contribution**

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The energy levels of a weak-coupling Fröhlich polaron in a uniaxial anisotropic semiconductor with complex structure, placed in a d.c. magnetic field directed along the optical axis, are obtained in the context of the improved Wigner-Brillouin perturbation theory.The discussion is restricted to the lower branch of the magnetopolaron spectrum. The q-2D behavior of the electron gas is taken into account by considering a finite extent along the optical axis of the electron wave function.

26EP10   **Potential Energy Relief and Stability of Modulated Structures in Quartz**

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A molecular dynamics study at low temperatures for quartz crystal is provided. A variety of modulated phases is found to be stable between α- and β-phases. Keeping external conditions constant and regarding the principle of least action, we transform one stable modulated or homogeneous structure into another moving the equilibrium atomic positions along the eigenvector of the corresponding soft mode. This allows us to reveal the potential energy relief, which is significantly nonlinear near phase transitions, and to estimate temperature intervals of stability of each phase. In particular, we show that between α- and β-phases, the structures with modulation period other than 3 unit cells are hardly observed in experiments at real temperatures since thermal fluctuations eliminate their narrow intervals of stability.

26EP11   **Pendellosung Beats due to Recoil and Confirmative Cryogenic Experiment**

Tetsuo Nakajima

wakkanai

A modified Bragg law into which recoil of atoms is introduced is expressed by $2d\sin\theta_B = \lambda(1+\delta)^p (\delta \ll 1)$, where δ is the rate of the partial charge of recoil defined by the ratio of number of the incident photons to that of the whole crystal atoms and p the multiplicity of the diffraction. Therefore, relative change of wavelength $\Delta\lambda/\,lambda$ is expressed by δp, which is obtained to be $1.76 \cdot 10^7$ for GaAs. Based upon the Kato-Lang relation, $\Delta\lambda/\,lambda$ is expressed by δ/t_0, where t_0 is the extinction distance. A value from this for GaAs is obtained to be $1.63 \cdot 10^7$. Excellent agreement is found between these experimental results.It is proposed that a confirmative experiment is an observation of gradual disappearance of beats by recoil-free diffraction due to slow enhancement of rigidity by lowering low temperature.

Pyroelectric Properties of Sol-Gel Derived Lithium Tantalite Thin Films

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Lithium tantalite ($LiTaO_3$) thin films ($\sim 0.5 \mu$m) have been successfully deposited on $Pt(111)/SiO_2/Si(100)$ substrates by means of sol-gel spin-coating technology. Figures of merit for infrared detector were studied on the $LiTaO_3$ thin films. The films have high figures of merit F_v of 2.1×10^{-10} C·cm/J and F_m of 2.4×10^{-8} C·cm/J because of relative low-dielectric constant (ϵ_r) of 35 and high pyroelectirc constant (γ) of 4.0×10^{-8} C/cm^2·K. High sensitive pyroelectric infrared detectors were fabricated by using the $LiTaO_3$ thin films. The detectors have a large voltage reponsivity R_v of 4584 V/W at 20 Hz. A high specific detectivity D* of 4.23×10^7 cm·Hz$^{1/2}$/W at 100 Hz has been attained.

Electronic properties of super-hard carbon nanocrystallite film

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The carbon nanocrystallite(CNC) film is a new type of synthetic carbon material. Recently it has been found that the film has large electronic conductivity ($\sim 10^3$[S cm^{-1}]) at room temperature while its hardness is comparable to that of Diamond. The CNC film consists of nano scale graphene sheets vertically oriented to the film surface, but little is known about the mechanism of the electronic conductivity. In this paper, we report the temperature dependence of electronic conductivity from 500 K down to 1.7 K. While hopping conductivity has been observed at low temperature region(T< 200 K), conductivity increases with decreasing temperature at T> 250 K. Such a metallic behavior has never been observed in other diamond-like carbon(DLC) materials.

Characterization of ZYX Grade Exfoliated Graphite for Studies of Two-Dimensional ^{3}He at Ultra-Low Temperatures

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Grafoil is widely used as an adsorption substrate for experiments of 2D ^{3}He at ultra-low temperatures because of its large surface area and moderate thermal conductivity. However, the relatively small single crystalline (platelet) size ($\simeq 10$ nm) makes it unsuitable for experiments to search for possible superfluidity in 2D ^{3}He, since the expected superfluid coherence length is longer than 100 nm. We have characterized a ZYX grade exfoliated graphite, whose platelet size is as large as 100 - 1000 nm, by measuring the specific surface area and electrical resistivity along the c-axis as a function of density. At a density of 1.1 g/cm^3, we found that they are 2 m^2/g and 2×10^{-5} Ωm, respectively, which meet the requirements for ultra-low temperature usage below 1 mK.

26EP15   **Thermal Conductivity of Bulk GaN Single Crystals**

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Recently, the group III nitrides have attracted much attention because of their application to electronic and optoelectronic devices. One of the properties important from both fundamental and applied perspectives is thermal conductivity, κ. We have measured κ in the temperature range 4–300 K of GaN bulk single crystals grown by high–pressure, high–temperature synthesis. Up to now, reliable data on $\kappa(T)$ in GaN were not available. Obtained results (1600 W/Km at 45 K) are the highest κ values reported on GaN material. A correlation between intrinsic (Umklapp scattering) and extrinsic (phonon–defect scattering) factors and high κ values is discussed. [The work was supported by KBN, Grant No. 7 T08A 008 21].

26EP18   **Study of disorder effects in titanium films resistivity**

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The resistivity of titanium films between 1.2 and 300 K have been measured. Samples with different residual resistivity, residual resistivity ratio, and temperature behavior have been obtained changing parameters of the fabrication process. The results are investigated in the framework of the electron-phonon-impurity interference theory. The T^2 behavior predicted by such theory is found in the temperature range between 4.6 and 30 K. Some samples also show an increase of resistivity for temperature lower than 12 K due to the Kondo effect.

26EP19   **Direct comparison between potential landscape and local density of states in a disordered two-dimensional electron system**

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The local density of states (LDOS) of the adsorbate induced two-dimensional electron system (2DES) on n-InAs(110) is studied by low-temperature scanning tunneling spectroscopy. The LDOS exhibits irregular structures with fluctuation lengths decreasing with increasing energy. We measure the potential landscape of the same 2DES area with the help of the tip induced quantum dot and compare with the expected LDOS from the single particle Schrödinger equation.

Low Temperature Transports in Fullerene Thin Film FET

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We have studied the low temperature transports in fullerene thin-films evaporated in a high vacuum and observed a high mobility electron transport controlling carrier concentration by using field effect transister (FET). Channel mobility in our FET sample is estimated about 0.1 cm^2/Vs and is slightly higher than previous study of n-channel fullerene FET. The low temperature transport shows a thermal activation and the activation energies of the transport are ranging from 0.4 to 0.2 eV. We consider that a certain mid gap state should be related to the low temperature transport and/or an oxidized insulating layer might affect to the carrier scattering process.

Using the Second Sound Property in Diluted Solution of ^{3}He in Superfluid ^{4}He for accurate thermometry

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After several years of research, the low temperature laboratory of BNM-INM has developed a new type of thermometer based on the propagation of sound in diluted solutions of helium-3 in superfluid helium-4. The instrument associates a sealed cell filled with diluted mixture of ^{3}He in ^{4}He to a built-in acoustic resonator. The significant experimental results are presented in this paper. The instrument has been used for checking the smoothness of the Provisional Low Temperature Scale of 2000. This instrument is, so far, mainly limited in accuracy by the quality of the theoretical model.

Thermoelectric and Transport properties of semi-conducting $Bi_{88}Sb_{12}$ alloy

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Homogenized samples of $Bi_{88}Sb_{12}$ were prepared by quenching and annealing at 523 K for 200 days. Both annealed and quenched samples are n-type semiconductors, and their properties show different temperature dependences between the low-temperature ($T < 70$ K) and high-temperature ($T > 70$ K) regions. Chemical potential was calculated from the measured carrier concentration, and found to change abruptly at 70 K, increasing rapidly with temperature. This explains the above differences in the two temperature regions in the framework of the Boltzmann theory, indicating $Bi_{88}Sb_{12}$ is strongly degenerate semiconductor.

26EP24   **ESR and Low Temperature Transport in Multi Walled Carbon Nano-Tube**

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Fundamental transport mechanism in multi walled carbon nano-tube has been studied by means of electron spin resonance (ESR) and low temperature magneto-transport in order to discuss on the transport properties in the tube. After thermal annealing, the transport in the tube shows an ordinal metallic conduction as well as in Fermi gas system. And the g-value and the line width for the ESR signal are gradually increased after the annealing. This also can be originated from a conduction electron system in the nano-tube.

26EP25   **New Crystal Topologies and the Charge-Density-Wave in NbSe$_3$**

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We successfully synthesized new crystal forms of NbSe$_3$, which is a well-known charge-density-wave conductor. The new forms are basically a loop of diameters 10-200 μm with/without a twist (ex. ring, Möbius strip). Their distinctive topology seems to offer systems for studying possible new quantum phenomena. Samples were obtained by chemical vapor transportation method and identified as NbSe$_3$ crystals by electron diffraction. SEM studies revealed that a loop is formed from a NbSe$_3$ whisker that wraps around a droplet of selenium by forces of surface tension. Also we observed that a twist is introduced during this spooling process. Moreover, we performed transport measurements on the materials and found that, exclusively in samples with a twist, T$_{CDW}$ is lower by a few kelvins than that of NbSe$_3$ whiskers. We suggest that the anomaly originates in local strain due to the twisted topology.

26EP26   **Magneto Caloric Effect in $(Dy_xGd_{1-x})_3Ga_5O_{12}$ for Adiabatic Magnetic Refrigeration**

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Large magneto caloric effect has been observed in $(Dy_xGd_{1-x})_3Ga_5O_{12}$ garnet single crystals below 4 K. For $x = 0$, $Gd_3Ga_5O_{12}$ has a broad and large specific heat around 0.85 K coming from geometrical frustration, while $Dy_3Ga_5O_{12}$ ($x = 1$) shows a typical λ type anomaly at 0.37 K. By substituting Dy for Gd ($0 < x < 1$), it was observed that magnetic entropy change by the external magnetic fields could be enhanced. In the case of 1 T and $x = 0.25$, magneto caloric effect was about twice larger than that of 1 T and $x = 0$. The entropy diagram was obtained by heat capacity and magnetization measurements and the magnetic Carnot cycle for adiabatic demagnetization refrigeration will be discussed.

The Inverse Analysis of the Enclosed Cavity Perturbation Technique

26EP27

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For complex electrical conductivity measurements in the microwave and millimeter-wave region, the enclosed cavity perturbation technique is one of the most widely used. In this technique, we introduce a sufficiently small sample into a cavity resonator, and measure the change of the resonant frequency and that of the Q factor of the resonator. In general, the data-analyse prosess to obtain complex conductivity of the sample is an inverse eigen value problem of Maxwell's equations, and many serious problems are left unresolved. We studied the inverse analysis based on Double Sphere Model where the exact solutions of full Maxwell's equations can be calculated analytically.

Design of 4GPa class hybrid micro-high pressure cell for dilution refrigerator

26EP28

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We contracted the piston cylinder type hybrid high pressure cell using the Ni-Cr-Al alloy. It was designed in the miniature cell; 67mm in length and 25mm in outer diameter for using it with dilution refrigerator. We have succeeded the resistivity measurement under hydrostatic pressure up to 3.76 GPa at temperatures down to 33 mK.

Superconducting phase diagram of $La_{2-x}Sr_xCuO_4$ studied using a single crystal with carrier concentration gradient

26EP29

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Superconducting as well as magnetic properties of high-T_c cuprates sensitively depend on carrier concentration particularly in the vicinity of phase boundaries. For the precise determination of phase diagram, therefore, we need to utilize number of single crystals with different carrier concentration. In this report, we propose an alternative and more efficient study using a carrier concentration-graded single crystal. We grew a single crystal of $La_{2-x}Sr_xCuO_4$ with a spatial gradient of x from $\sim$0.07 to 0.30. Measurement of superconducting transition temperature in a small region along the concentration gradient revealed a dramatic degradation of superconductivity at around x$\sim$0.115 much more clearly compared to the previously determined phase diagram.

26EP30   **Structural and electrical propaties of TaSe$_3$ ring crystals**

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We have investigated structural and electrical properties of TaSe$_3$ ring crystals which are basic form of topological materials such as möbius crystals, 2π-twisted loop crystals and so on. We cut the ring crystals by Focused Ion Beam and observed them become arc shape after cutting. This result means that bending stress remains homogeneously inside the ring crystals. Moreover we found that circular dislocations have induced in thick rings from thickness-distribution of samples. The measurement of the electrical property shows that thin rings and whiskers are superconducting but thicker rings are non-metallic behavior like a CDW. We suggest that the thickness can be a main factor of changing electrical property in TaSe$_3$ ring crystals, in the relation of the bending stress and/or the circular dislocations.

26EP31   **Cryogen-free Two Stage Adiabatic Demagnetization Refrigerator**

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A cryogen-free adiabatic demagnetization refrigerator (ADR) has been developed using the pulse tube cryocooler for the pre-cool. Gallium Gadolinium Garnet (GGG) and the Ferric Ammonium Alum (FFF) were used for the first stage and the second stage of the refrigerator respectively, and both stages are supported with Kevlar strings. The fridge reaches base temperatures below 50 mK, and the second stage will remain below 100 mK for more than two days. The vibration generated by the pulse tube cryocooler and its compressor is small enough that the base temperature of the fridges is not affected, while the holding time of the fridges will be improved when it is supported by a vibration stand. A 1/4" diameter OFHC copper rod serves as the sample holder. Port(s) is included in the system for the users where snouts need to be installed. Design and performance details of the systems will be discussed.

26EP32   **Cryogen Free He-3 cryostat**

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A new type of He-3 cryostat has been developed. The system does not need any liquid nitrogen or liquid helium to cool down, but employs a G-M cryo-cooler to condense the He-3 gas. After the He-3 gas is condensed, an internal charcoal sorption pump is used to pump the He-3 pot down to 300 mK. The normal holding time varies from 8 to 16 hours, depending on the amount of He-3 installed in the system. Details of the design, fabrication, operation and performance will be discussed.