Field desorption of lithium fluoride

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Layers of lithium fluoride (LiF), ~10 nm thick, were field desorbed from iridium substrates at temperatures between 25 and 600 °C. The electric field was increased until desorption of the salt layer occurred. Combined mass spectroscopy and field desorption microscopy characterized the desorption process. During desorption, ions of the form $(\mathrm{LiF})_n\cdot\mathrm{Li}^+$, $n=1-4$ are created. The field strength required for desorption is higher at lower temperatures and decreases as the temperature of the substrate is increased. Evidence for a piecewise removal of the LiF layer is presented. For thick salt layers, Li^+ ions are frequently detected. An ion production mechanism based on ionic conduction of a salt layer in a high electric field is presented. © *1995 American Vacuum Society.*

I. INTRODUCTION

The behavior of salts under the influence of high electric fields is of scientific interest and has been studied before.[1–7] Previous work includes field desorption of alkali halides under a variety of experimental conditions.[8–13] Field desorption of lithium fluoride is of particular current interest[14,15] because LiF is currently used as a Li^+ ion source for light-ion inertial confinement fusion (ICF) experiments on the Particle Beam Fusion Accelerator II (PBFA II).[16–18] In the ICF experiments, Li^+ ions are created by applying a high electric field to a LiF-coated substrate at 25 °C.

In this article, field desorption of LiF films at elevated temperatures is investigated. The method used in these experiments is to increase an electric field linearly with time (at a constant temperature) to cause LiF adsorbed on a metal surface to desorb in a controlled fashion. This technique is called isothermal ramped field desorption.[19] It produces spectra similar to those obtained by thermal desorption spectroscopy where the temperature of the substrate is raised in a controlled way to desorb the adsorbate.[20] In the experiments that will be described, LiF is preadsorbed onto an Ir substrate and held below the temperature at which thermal desorption occurs. The LiF coating is then desorbed isothermally by applying a high electric field whose magnitude increases linearly with time. In the process, positive ion clusters are produced. The spatial distribution of the ions created can be viewed with nanometer scale resolution, utilizing the principle of a field desorption microscope.[21]

II. EXPERIMENT

A field emitter tip is used to create an electric field high enough to desorb species from its apex. The tip is formed by electrochemically etching an Ir wire. The tip is then annealed and field evaporated in vacuum to clean and smooth its surface[22,23] and to obtain a field–voltage calibration according to the relation[24]

$$F\approx\frac{V}{\kappa R}\,, \tag{1}$$

where F is the electric field at the tip apex, V is the voltage applied between tip and counter electrode, and $\kappa R\sim 500$ nm. If κ is assumed to be ~5,[24] the apex radius of curvature of the tip, R, is ~100 nm. The field emitter tip is mounted onto a wire loop and placed in an ultrahigh vacuum (UHV) chamber at ~ 10^{-9} Torr. The tip is cooled to 80 K by a cold finger filled with liquid nitrogen, but it can be heated by passing an electric current through the wire loop. A LiF reservoir (which has been heated in vacuum to ~900 °C to thoroughly degas and purify the salt) is mounted opposite the tip apex. LiF vapor is introduced to the system by electrically heating the reservoir of LiF to near its melting point. At this temperature, the vapor created from the evaporating sample is composed of mostly monomers and dimers of nondissociated LiF molecules.[25] They condense onto the tip where they form a salt layer with a layer thickness of ~10 nm. The thickness of each layer is monitored with a thin film thickness monitor placed behind the specimen tip.[26] LiF layers created under these experimental conditions are polycrystalline and spatially fairly uniform.[15,27] After the salt layer is formed, the LiF vapor is pumped out and a current is passed through the wire loop until a desired temperature of the specimen between 25 and 800 °C is reached. A positive high voltage ramp is then applied to the tip at a ramp rate of 50 V/s. An electric field is eventually reached that is sufficient to initiate desorption of the LiF layer. Positively charged ions are produced and are accelerated radially away from the tip. They can either be focused and analyzed in a mass spectrometer, or they can be directed toward an imaging detector to produce a highly magnified image of the desorption event.[21] In both cases, the ion current can be recorded as a function of applied voltage. A detailed description of the apparatus used for this experiment has been given elsewhere.[28,29] The mass spectrometer is calibrated by desorbing LiF salt with the naturally occurring isotopes of ^{6}Li (6%) and ^{7}Li (94%) and evaluating the relative intensities of different mass peaks that belong to the same chemical compound.[30] After each desorption event, the field emitter tip is heated to ~1000 °C in order to clean the tip surface and the wire loop of residual salt. To characterize the surface of the Ir tip used in these experiments, a field ion micrograph of the tip apex, imaged in 10^{-4} Torr He at 80 K (shown in Fig. 1), was recorded before and after the experiments described in this article were performed.

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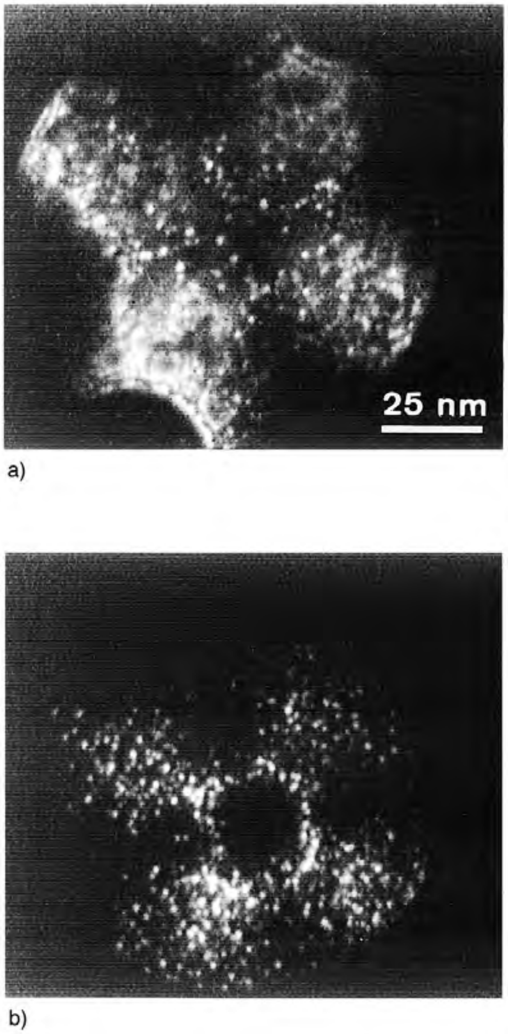

FIG. 1. Field ion micrograph of the Ir field emitter tip (imaged at 80 K, 10^{-4} Torr He, 25 kV) used in these experiments. (a) Tip before the salt desorption experiments, and (b) tip after the salt desorption experiments.

III. RESULTS

A. Tip characterization

Both field ion images in Fig. 1 were obtained at the same imaging voltage. The apex radius of the tip did not change noticeably in the course of the experiment, but the tip surface underwent some changes [compare Figs. 1(a) and 1(b)]. The repeated heating of the tip to 1000 °C to clean the surface after each salt deposition probably caused some additional annealing of the tip. Moreover, the dissociation of hot LiF may have been responsible for attacking the Ir surface and thereby causing the changes observed. The main concern with respect to this experiment, however, is the field–voltage calibration, which was apparently unchanged throughout the experiment. All of the salt desorption data produced with this tip were reproducible as stated in Secs. III and IV.

B. Field desorption microscopy

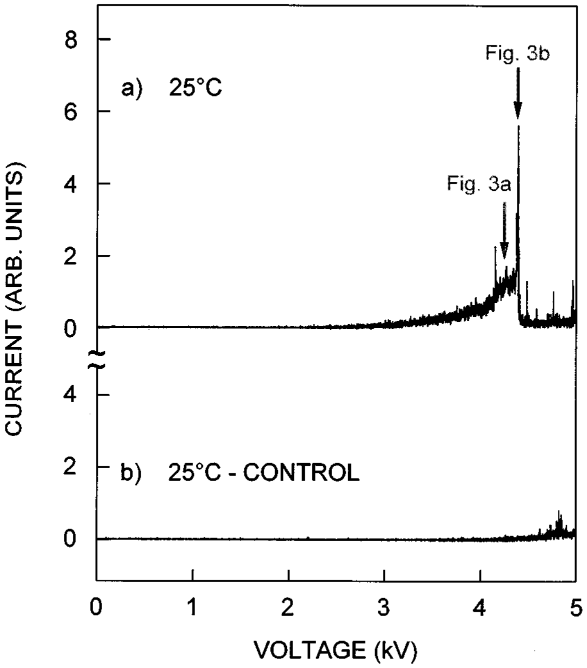

FIG. 2. Total ion current during LiF field desorption from the tip apex at 25 °C as a function of voltage. The voltage is raised at a rate of 50 V/s. (a) Desorption of a 10 nm thick LiF layer and (b) repeat of (a) without recoating the tip with LiF.

Figure 2(a) shows a plot of the ion current when a voltage, linearly increasing with time, is applied to a LiF coated tip at room temperature. Desorption starts at a threshold voltage of ~2.5 kV, and as the voltage is increased, the ion current increases until the voltage reaches ~4.4 kV [Fig. 2(a)]. Field desorption micrographs show that desorption during that time occurs spatially uniformly over the area of the tip apex viewed [Fig. 3(a)]. (For comparison, a field ion micrograph of the same region of the tip is shown in Fig. 1.) Before the ion current decreases, it reaches a sharp maximum at 4.4 kV, which corresponds to the micrograph shown in Fig. 3(b). Afterwards, a small and fairly steady ion current is observed upon raising the tip voltage to 5.0 kV. A control experiment, where the tip voltage was raised in the same manner, was performed immediately thereafter, but the LiF coating at the tip apex was not renewed. Figure 2(b) shows the resulting ion current as a function of applied voltage. Only a small ion current is detected at voltages greater than ~4 kV.

The experiment is repeated for desorption temperatures of 250, 400, and 600 °C. Figure 4 shows spectra obtained at 250 and 400 °C. The desorption kinetics is obviously more complex than at room temperature. Desorption starts at some threshold voltage, and the current increases monotonically until a certain voltage is reached. The current reaches a maximum and decreases rapidly. However, a substantial amount of ion current is still emitted, and after going through several maxima, the current finally drops to near zero. From field desorption micrographs (Fig. 5) we see that at 250 °C desorption initially occurs spatially uniformly. After the first current maximum shown in Fig. 4(a), the LiF layer has been removed from a small area at the tip apex while areas at the periphery of the viewing region still emit ions [see Fig. 5(b)]. This process of piecewise salt layer removal repeats itself

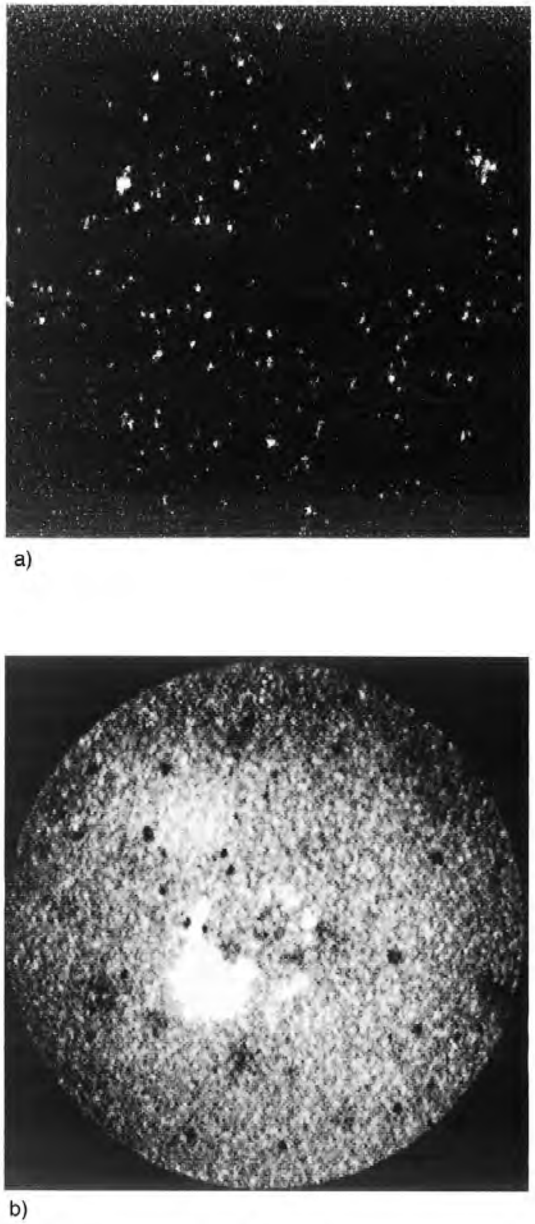

FIG. 3. LiF field desorption micrographs at 25 °C. (a) Desorption occurs spatially uniformly until (b) a desorption rate is reached sufficiently high to remove the entire salt layer from the tip apex. [Compare with Fig. 2(a) for the dynamics of the process.]

several times until no salt layer is left near the tip apex within the viewing area [see Figs. 5(b)–5(d)]. Ion emission at 400 °C is similar except when desorption starts; it is not spatially uniform [Fig. 6(a)]. However, with increasing voltage, desorption becomes spatially fairly uniform, and it proceeds similarly to that as at 250 °C [Figs. 6(b)–6(d)]. As in the room temperature case, control experiments do not show a significant ion current. Desorption spectra obtained at 600 °C yield a fair amount of ion current; however, desorption images suggest that ion emission does not originate at the tip apex but, possibly, at the support structure to which the tip is spotwelded and which is near tip temperature. In addition, control experiments at this temperature (where the voltage is raised a second time without recoating the tip with LiF) exhibit features similar to a freshly coated tip.

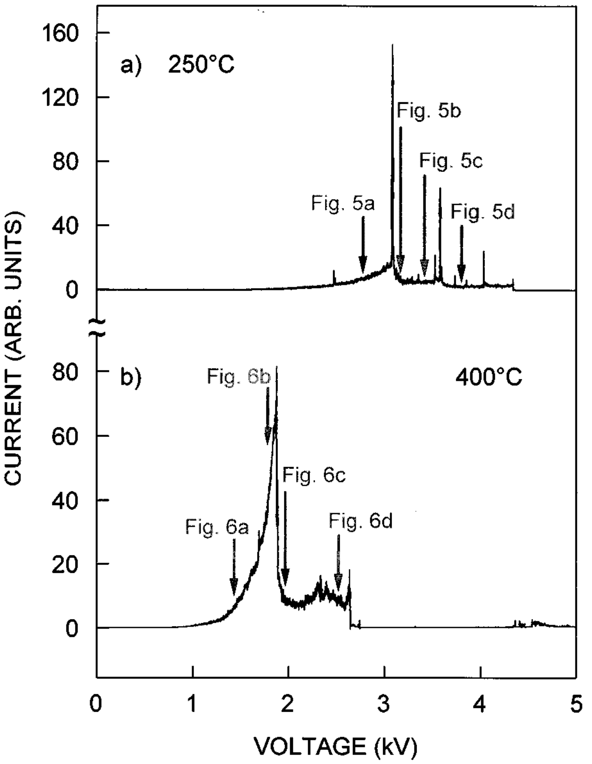

FIG. 4. Total ion current during LiF field desorption from the tip apex as a function of voltage at (a) 250 °C and (b) 400 °C. The voltage is raised at a rate of 50 V/s.

C. Mass spectroscopy

Before proceeding it should be pointed out that, for mass spectroscopy, an aperture must be used (for focusing purposes) such that only a small area in the center of the tip apex (~15 nm in diameter) is under investigation.

Figure 7 shows a representative mass-resolved desorption spectrum at 250 °C. For this experiment, the ion current is recorded as a function of applied voltage while the mass spectrometer is tuned to one particular mass-to-charge ratio. Afterwards, the tip is recoated with LiF and the ion current is recorded for a different mass-to-charge ratio. This process is repeated until spectra for all desorbing mass species are recorded. (To ensure that no mass species are left out, an experiment is performed with the dispersion of the mass spectrometer adjusted such that all mass species between 6 and ~120 amu can be viewed at the same time. This mode of operation, however, is not suitable for recording the ion current of one individual mass species as a function of applied voltage.) The total ion current for one particular mass-to-charge ratio during a desorption event can be obtained by integrating an individual spectrum in Fig. 7. This yields an abundance of 61% $(\mathrm{LiF})\mathrm{Li}^+$, 25% $(\mathrm{LiF})_2\cdot\mathrm{Li}^+$, 13% $(\mathrm{LiF})_3\cdot\mathrm{Li}^+$, and 1% $(\mathrm{LiF})_4\cdot\mathrm{Li}^+$ at 250 °C. All percentages are reproducible to within ~20% of their value. It is gener-

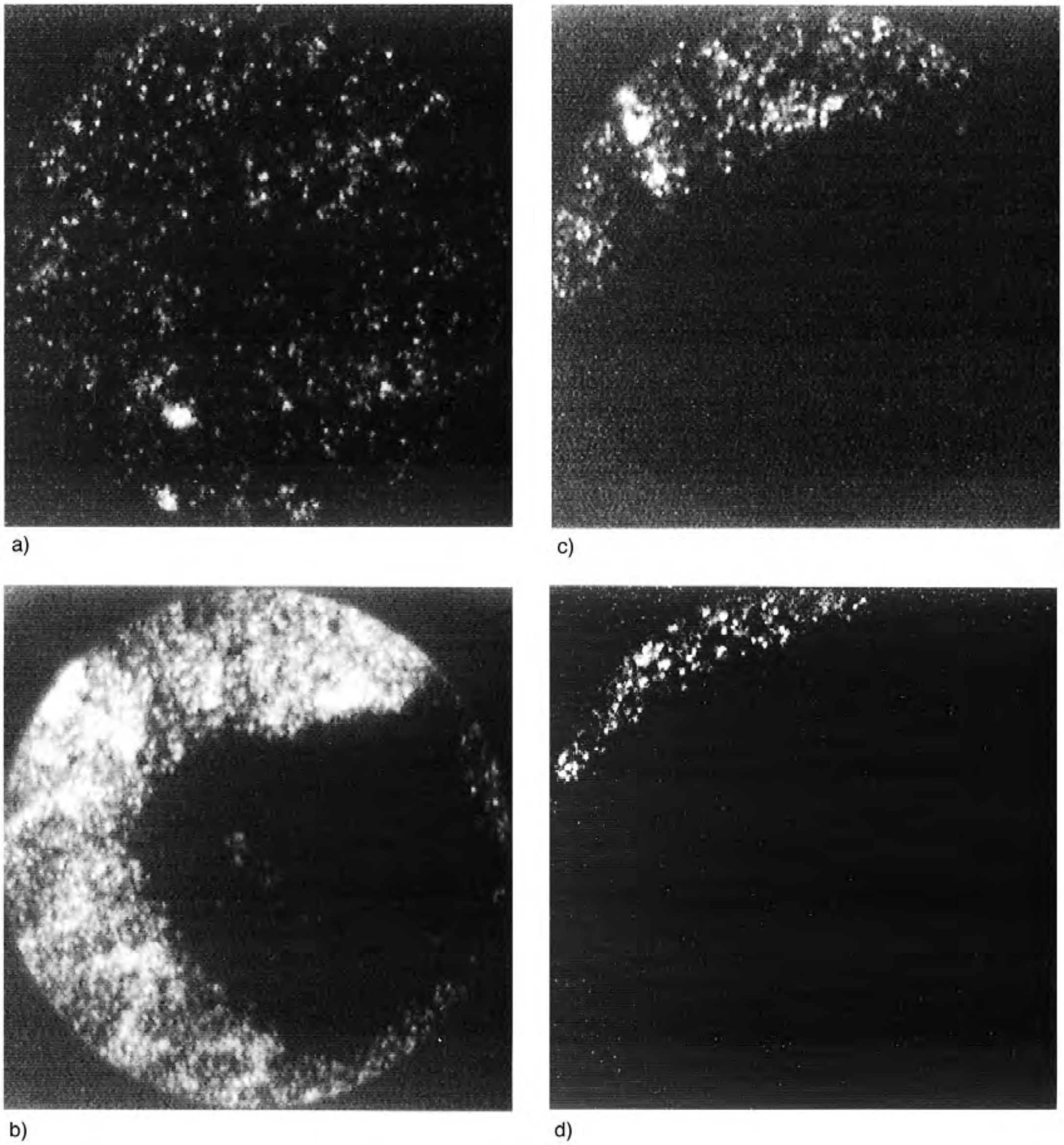

FIG. 5. LiF field desorption micrographs taken at 250 °C. (a) Desorption starts spatially uniformly until (b) a portion of the salt layer is completely removed from the center of the tip apex. (c),(d) Further sudden disappearance of ion emitting areas suggest a piecewise removal of the LiF coating as the tip voltage is raised.

ally observed that the larger ion clusters become less abundant with respect to the cluster $(LiF)Li^+$ at higher desorption temperatures.

D. Temperature–field dependence of desorption

If the field at the tip apex is calibrated according to Eq. (1) and the presence of the LiF coating is neglected in the calculation, a field–temperature dependence of desorption is obtained as shown in Fig. 8. Data points shown as filled circles represent the threshold field for desorption (i.e., where an ion current significantly higher than background can be detected). Data points shown as crosses represent the electric field where the entire LiF coating has been removed from the tip apex (desorption stops). All data points are recorded for desorption from a small region at the tip apex (~15 nm in diameter), corresponding approximately to the center region of the tip shown in the micrograph in Fig. 1. From Fig. 8 it is apparent that a higher desorption field is needed at lower desorption temperatures and vice-versa.

E. Thick LiF layers

If the LiF layer thickness is increased from 10 to greater than 50 nm, the desorption characteristics change drastically and are much less reproducible. For example, at room temperature, desorption occurs in a single burst of ions as the voltage is slowly increased [~1 MV/(cm s) at the tip apex]. At elevated temperatures (>250 °C), upon raising the voltage, an increasing ion current is observed as shown in Fig. 9. The ions are initially composed of $(LiF)_n \cdot Li^+$ cluster ions, $n=1–4$. As the voltage is increased further, their composition changes and Li^+ ions appear. At some voltage, only Li^+ ions are emitted, until at even higher voltages no ion current

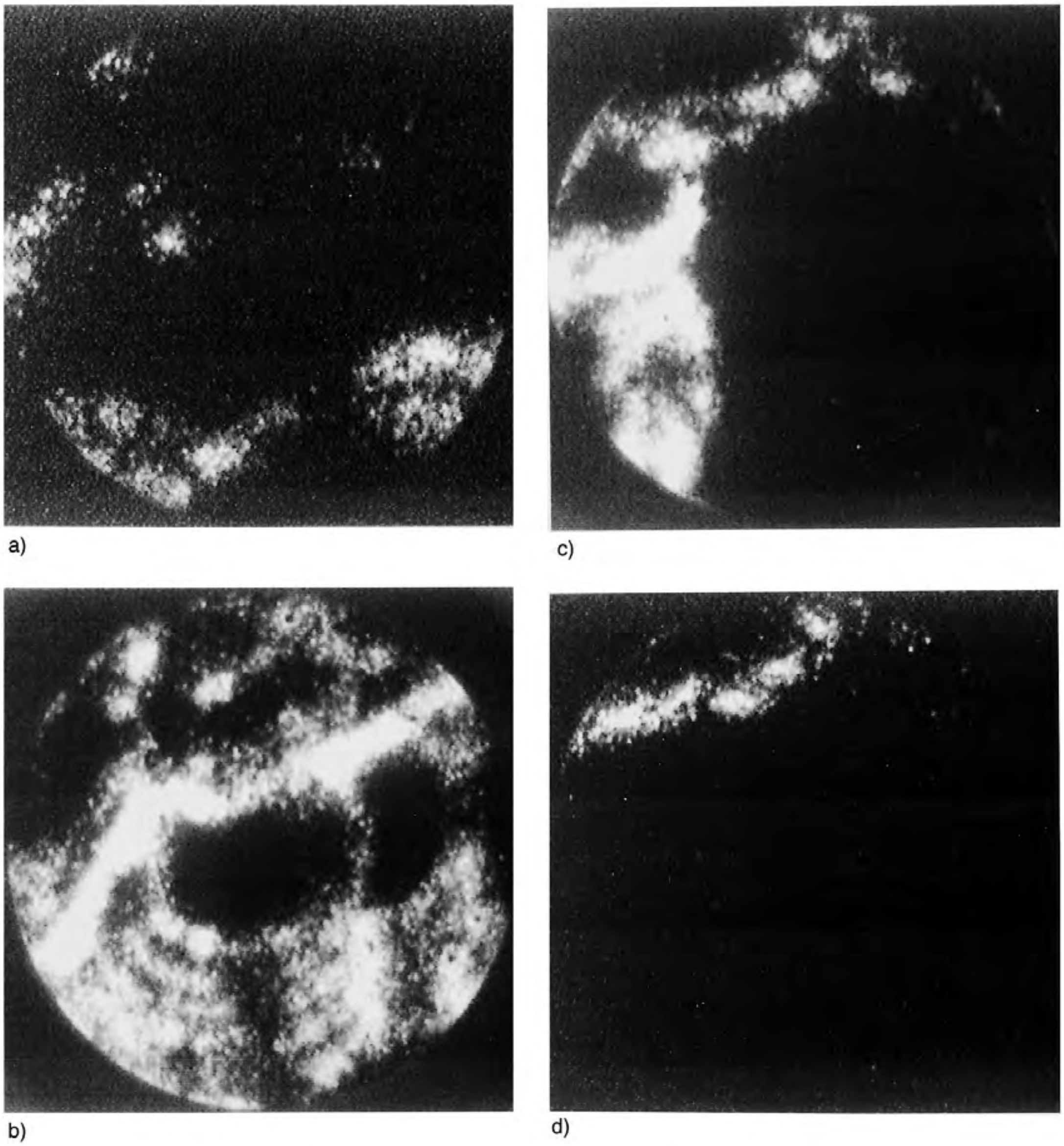

FIG. 6. LiF field desorption micrographs taken at 400 °C. The dynamics are similar to desorption at 250 °C except that ion emission occurs as more localized here; this is probably due to field enhanced regions on the LiF layer surface.

is observed. Reducing the voltage reverses the process: Li^+ is detected first and, as the voltage is decreased, Li^+ disappears and $(LiF)_n \cdot Li^+$ ion clusters appear instead. This process of raising and lowering the voltage can be repeated several times with the same qualitative results. The magnitude of the ion current appears to be strongly dependent on temperature, initial layer thickness, and history of the sample and cannot be reproduced well. Maximum ion currents of up to several picoamperes have been observed (originating within the viewing area of the tip, see Fig. 1). Above ~550 °C, cluster ions are never observed. Li^+ ions are detected up to temperatures of ~750 °C. At those high temperatures, the ion current decreases rapidly as a function of time, and the tip must be recoated with a fresh LiF layer often.

IV. DISCUSSION

An electric field on the order of 100 MV/cm applied to a LiF substrate at room temperature is sufficiently high to ionize surface molecules and to desorb them.[14] The electric field inside the salt will reach or exceed 10 MV/cm at 25 °C, which is in excess of the breakdown field strength of LiF of 3 MV/cm at this temperature,[1] and ions can be produced by electrical breakdown as well. In addition, at electric fields of 100 MV/cm the electrostatic pressure exerted on the LiF surface is enormous,[23] and field induced fragmentation of the salt layer may occur.[14] At elevated temperatures, many alkali halide crystals become ionic conductors.[10] Also, the electric field strength for the removal of a salt layer becomes lower at higher temperatures.[9] As a result, field desorption will be the dominant mechanism of ion production at elevated temperatures.

The removal of the salt layer by the electric field in this experiment is consistent with those previous observations. Ion production from LiF films at 25 °C under almost the same experimental conditions (ramped field desorption) has been studied before.[14] The reasons the experiment was con-

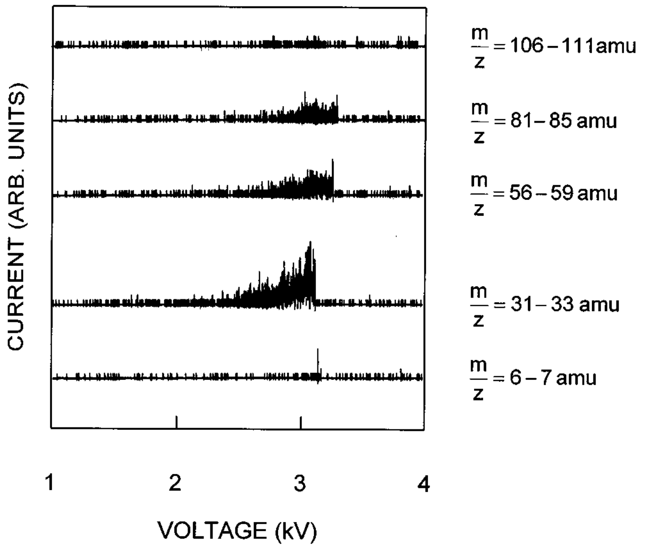

FIG. 7. Mass resolved desorption spectrum of LiF at 250 °C. The individual mass-to-charge ratios correspond to the isotopes of Li^+ and $(LiF)_n \cdot Li^+$, $n=1-4$ (from bottom to top). (The variation in the voltage at which desorption ceases for the different mass species is not significant and defines the error of the measurement.)

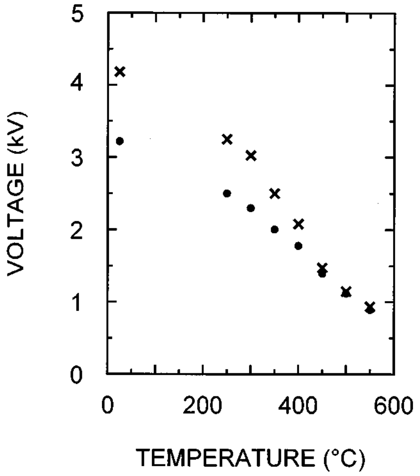

FIG. 8. Onset field (●) and field at which desorption ends (×) as a function of desorption temperature.

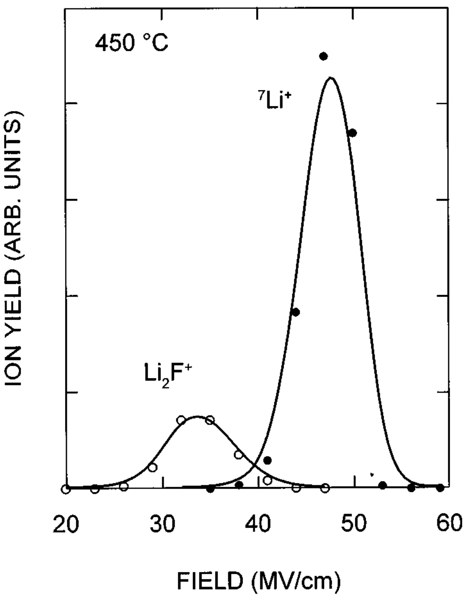

FIG. 9. Ion yield for initially very thick (>50 nm) LiF layers on the tip. The electric field can be cycled between 20 and 60 MV/cm several times with the same qualitative result without recoating the tip with LiF. Clusters larger than $(LiF)Li^+$ are not shown and generally appear and disappear together with $(LiF)Li^+$.

ducted again are: (1) the ion species created were mass-analyzed in this experiment; (2) to provide a coherent set of data with our experimental results at different temperatures; and (3) the result presented here is quantitatively reproducible. In an experiment reported before, ". . . as the voltage was increased, ion emission began sporadically and faintly, then became spatially uniform . . . The emission remained uniform for a period of time on the order of second, after which it rapidly diminished and recommenced, in a burstlike manner."[14] These observations are nearly identical to our case, except that merely one single large burst of ions is observed consistently at the end of desorption [Fig. 3(b)]. This and the reproducibility of the desorption spectrum in Fig. 2(a) (reproducible within a few % of the desorption voltage) is likely to be due to the relatively small layer thickness (10 nm) on a tip with an apex radius of curvature of ~100 nm. Pregenzer *et al.* have used various thicknesses up to 70 nm of the LiF layer in their investigation,[14] and the ratio of layer thickness to apex radius of the tip was large (1:3 to 1:1 vs 1:10 in our experiment). This implies that the electric field gradient across the layer is not as large in our case, which may explain the more consistent results here. For reproducible results it also appears to be important that the layer thickness is kept below ~50 nm to ensure spatial uniformity of a LiF layer created by vapor deposition on a tip.[15]

The spectrum in Fig. 2(a) is interpreted as field desorption of the ion clusters $(LiF)_n \cdot Li^+$, $n=1-4$, from the layer surface, up to the point where the peak current is observed [Fig. 3(b)]. There, apparently field–stress induced removal of the remaining layer occurs. Electrical breakdown may also be possible, but the usual breakdown mechanisms cannot apply because the mean free path of electrons across the layer is too short and the potential difference across the layer is only a few volts (10 MV/cm = 10 V/10 nm). The ion current observed after the main peak is either due to LiF more tightly bound to the Ir surface or due to field-induced migration of LiF molecules from along the tip shank as shown schematically in Fig. 10. In the control experiment [Fig. 2(b)], migration and subsequent desorption cause the small ion current observed above 4 kV. (If a LiF layer tightly bound to the surface did not desorb upon raising the voltage the first time between 4 and 5 kV, it will not desorb in the control run either.) The control experiment clearly shows that the majority of the 10-nm-thick LiF layer has indeed been removed by the electric field.

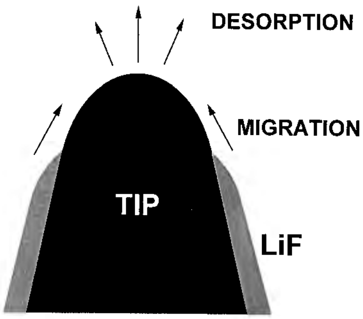

FIG. 10. Schematic of the field emitter tip with a LiF coating after the salt layer from the tip apex has been removed. For thick salt layers especially, migration of LiF molecules from the tip's shank and their subsequent desorption can lead to an appreciable ion current.

At higher desorption temperatures, the number of ions produced increases significantly [Figs. 4(a) and 4(b) vs Fig. 2(a)]. At elevated temperatures, salts become ionic conductors,[10] but also the mobility of surface molecules becomes larger, and they can diffuse into the ionization zone.[8] The desorption spectrum at 250 °C resembles the one at 25 °C, except that now only pieces of the salt layer are removed where the ion current spikes are, as it is revealed in field ion micrographs [Figs. 5(a)–5(d)]. After each burst of current, the ion emitting area of the tip becomes smaller. Observing the field ion micrographs in real time with a video camera actually shows how the ''dark'' non-ion emitting area of the tip expands rapidly during a current spike, and then this area remains approximately constant in size until the next spike occurs. A piecewise LiF layer removal in comparably high electric fields has been directly observed at elevated temperatures in the transmission electron microscope.[31]

Since increasing the desorption temperature lowers the electric field necessary for desorption (field desorption is a thermally activated process), the electric field stress on the salt sample is reduced and therefore a less catastrophic behavior is observed. Especially at 400 °C, the ''burstlike'' manner of ion production has almost ceased [see Fig. 4(b)], and a field desorption mechanism should account for the majority of the recorded ion signal.

The local nonuniformity of ion emission at the beginning of the desorption process at 400 °C is thought to be due to protuberances on the salt surface where the electric field is enhanced. The formation of protuberances during salt desorption has been suggested before.[13] Even though protuberances could exist at lower desorption temperatures, they can only exist until the molecules which form the protuberance are field desorbed at low temperature. On the contrary, at a higher desorption temperature surface migration of molecules (which will preferentially occur in the direction toward the high electric field created by the protuberances) can supply the protuberances with molecules so that a long lasting ion signal is observed from a particular emission site [Fig. 6(a)]. Only when the electric field is high enough on the entire tip apex, is a spatially more uniform emission observed [Fig. 6(b)].

When the temperature is raised further to 600 °C, it is believed that thermal migration is so dominant that sintering and possibly thermal desorption of the salt layer occur prior to applying an electric field. Sintering removes molecules from highly curved surface regions—mainly from the tip apex—to regions with lower curvature.[8] If the electric field gradient is not strong enough to counteract the thermal diffusion away from the tip apex, field desorption may originate at locations other than the tip apex. Another possibility is that thermal desorption causes the removal of the salt layer from surfaces of the tip and its support structure that are at a temperature of 600 °C. The parts of the tip support structure that are at a lower temperature will still have a salt layer on the surface from which migration to the hot regions of the tip support may take place. As a result, control experiments would yield similar ion emission currents again and again until the salt reservoir at the cooler surfaces were exhausted. This is consistent with the observation made in this experiment.

The ion species recorded during these desorption experiments are of the same structure as the ones found for field desorption of other alkali halide salts.[8,9] A remarkable difference is that, here, the single alkali ion, Li^+, is extremely weak in intensity or not detected at all. Also, ions of the form $(\mathrm{LiF})_n^+$, $n=1,2,\ldots$, are never observed. It has already been pointed out that field desorption mass spectra of salts are very sensitive to experimental conditions.[8] Since the experiments presented here are threshold experiments (which means that desorption is initiated at the minimum electric field required for field desorption at a given temperature), only reactions with a small activation energy will take place to create ions or ionic clusters. The reaction producing the $\mathrm{Li}_2\mathrm{F}^+$ ions in this experiment is likely to be analogous to the one suggested for other alkali halides:[12]

$$(\mathrm{Li}_i\mathrm{F}_j)^{(i-j)+}\rightarrow(\mathrm{Li}_{i-2}\mathrm{F}_{j-1})^{(i-j-1)+}+\mathrm{Li}_2\mathrm{F}^+,\quad i\gg j. \tag{2}$$

It is interpreted as a reaction occurring at the salt surface which is highly charged upon applying a high electric field.[12] This charged state of the lithium enriched salt surface presupposes ionic conduction of the salt layer.[10] In particular, the negative charges are assumed to be transferred to the salt–metal interface where F_2 or possibly metal fluoride may be formed, the former being released as a gas.[10,13]

The temperature–field dependence in field desorption, as exhibited in Fig. 8, is a well-known phenomenon. Field desorption is a thermally activated process. The binding energy of surface molecules or ions can be overcome by either supplying the ion with more thermal energy or by lowering the potential barrier by increasing the electric field strength.[23] As shown in Fig. 8, the beginning and the end of desorption of the salt layer occur at nearly the same electric field at higher temperatures, but at lower temperatures the electric field needs to be raised for some time from the beginning of desorption until the entire layer is desorbed. The reason is that desorption occurs more rapidly at higher temperatures once the threshold electric field has been reached; that is probably due to the better electrical conductivity of the sample. In addition, the previously mentioned sintering effect at higher temperatures could be responsible for the LiF layer being thinner than 10 nm at the tip apex so that less material is desorbed.

When the thickness of the salt layer is greater than ~50 nm, its morphology changes[15] (i.e., the layer is spatially less uniform), and obviously the amount of salt available for desorption increases. A less uniform salt coating on the tip surface, which can lead to growth of crystalline needles during vapor deposition,[15] is much more susceptible to field stress induced fragmentation due to locally high field gradients. Therefore, experiments with thick layers are expected to be less reproducible, as has been observed here and under pulsed field conditions for thick LiF layers.[15] In this experiment, no ion emission is observed at all at 25 °C for thick layers until a single burst of ions is detected; this burst represents the removal of the entire salt layer. It has been mentioned before that, if the thickness of an electrically insulating layer is too great, i.e., if it extends beyond the zone of ionization, no ion formation occurs.[8] Therefore, under these conditions a mechanism other than field desorption, such as electrical breakdown or field–stress induced fragmentation must be responsible for the layer removal. At higher temperatures where the salt layer becomes an ionic conductor the following mechanism is proposed: When the voltage is raised for the first time, the salt layer at the tip apex is field desorbed, creating ions of the form $(\mathrm{LiF})_n \cdot \mathrm{Li}^+$, $n=1-4$ (see Fig. 9). At higher electric fields, the increased surface charge density is established by a larger percentage of Li^+ ions with respect to F^- [see Eq. (2)] so that more single Li^+ are available for desorption. An alternate explanation for the greater abundance of Li^+ species is that a higher electric field will decrease the energy barrier for dissociation of LiF so that more single Li^+ ions are created. By that point, the original salt layer at the tip apex has possibly been desorbed, and LiF molecules are supplied from the tip shank by field induced migration (see Fig. 10). When the field at the tip apex is raised even further, the field will become high enough at the peripheral region of the tip apex to desorb ions. Salt molecules migrating there from the shank will therefore already be desorbed in the peripheral region of the tip apex and will not migrate all the way to the center of the tip apex. Field ion micrographs support this theory because the center of the tip apex does not emit ions at those high electric fields, whereas ion emission is still seen at the periphery of the tip apex. Lowering the electric field then allows the LiF molecules to migrate to the center of the tip apex where Li^+ ions can then be field desorbed. At even lower fields, the ratio of Li^+ to F becomes smaller at the surface of the salt layer (now created by migration) so that cluster ions containing fluorine are desorbed again. The reproducibility of the observations by raising and lowering the voltage especially indicates that a thick LiF layer along the tip shank acts as a reservoir from which migration supplies LiF molecules to the tip apex for desorption. At temperatures higher than ~500 °C, thermal desorption should lead to a rapid depletion of the reservoir, as seen in experiments with other alkali halide salts,[13] so that the LiF layer must be refreshed often. The observation that cluster ions are completely absent above 550 °C can be understood as an effect caused by the sintering of the salt layer. At high temperatures, without the field applied, the salt is likely to migrate away from the highly curved tip apex, and with the electric field turned on, only monomers of LiF can migrate back to the tip apex and dissociate. This general observation has been made before and has been interpreted this way.[8]

V. CONCLUSIONS

Field desorption of LiF films from field emitter tips has been investigated at elevated temperatures. It has been confirmed that LiF salt behaves more like an ionic conductor than an insulator with rising desorption temperature. The cluster ions produced in the desorption process, $(\mathrm{LiF})_n \cdot \mathrm{Li}^+$, $n=1-4$ are a result of operating at the threshold where a combination of temperature and electric field is just sufficiently high for desorption. For reproducible desorption, a thin coating of LiF on the field emitter is necessary. For applications of field desorption of LiF at elevated temperatures as a Li^+ ion source for light ion inertial confinement fusion, more experiments should be performed employing pulsed-voltage field desorption.

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