AIP Journal of Applied Physics

Results of Peak Field Measurements for Uniform and Bi-Periodic Deflecting Cavities

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Citation: Journal of Applied Physics **40**, 4989 (1969); doi: 10.1063/1.1657333
View online: http://dx.doi.org/10.1063/1.1657333
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TABLE I. Dielectric constants (ϵ').

	Tungstates				Molybdates		
	$CaWO_4$	$SrWO_4$	$PbWO_4$	$BaWO_4$	$CaMoO_4$	$SrMoO_4$	$PbMoO_4$
$\epsilon' \parallel a$ axis	11.7±0.1	25.7±0.2	23.6±0.3	35.5±0.2	24.0±0.2	31.7±0.2	34.0±0.4
$\epsilon' \parallel c$ axis	9.5±0.2	34.1±0.2	31.0±0.4	37.2±0.2	20.0±0.2	41.7±0.2	40.6±0.2
$\epsilon' \parallel c/\epsilon' \parallel a$	0.81	1.33	1.31	1.05	0.83	1.32	1.19

$BaWO_4$. The systematic anisotropy of the dielectric constants in relation to the divalent cation is also discussed.

The experimental methods and procedures have been described in Refs. 1 and 2.

All crystals were grown by the Czochralski method in air using inductively heated iridium containers. We were unable to grow $BaMoO_4$, using the same experimental arrangement which had been satisfactory for the other tungstates and molybdates. We feel that the difficulties involved in the growth of this material are due for the most part to the large thermal expansion and the anisotropy in the thermal expansion; a problem very similar to that of $PbMoO_4$ and $PbWO_4$.[3] Both DTA and high-temperature x-ray studies failed to show any phase transformations in the temperature interval 25°–1000°C where the internal fracture occurred. If the large thermal expansion and the anisotropy of the thermal expansion is the principal difficulty in crystal growth, then it should be possible to grow single crystals using more elaborate controls and suitable after heaters. Spectrochemical analyses of the crystals indicated the following impurities: $SrMoO_4$—Al, Ca, Cu, K, Mg, Si<0.001%, Na 0.001%–0.01%; $SrWO_4$—Cu, K, Mg, Si<0.001%, Ca, Na 0.001%–0.01%; $BaWO_4$—Ca, Cu, K, Li, Mg, Si<0.001%, Na 0.001%–0.01%.

Crystals were oriented by the Laue back reflection x-ray method. Samples were fabricated in the form of disks about 1 mm in thickness and 5–10 mm in diameter. Four specimens of each compound were prepared; two with the surface parallel to the c direction and two with the surface parallel to the a direction. Gold electrodes were applied by evaporation. Measurements were made at 1.59 kHz in air at 24.5°C. Additional measurements were made at 1 MHz and these were the same as the 1.59-kHz values within the experimental accuracy. The dielectric loss ($\epsilon' \tan\delta$) at both frequencies and for all specimens was 10^{-3} or less, therefore, the values reported are the static dielectric constants. The averages and deviations from the mean of two determinations are given in Table I together with the data from previous work for comparison. We have also calculated an anisotropy factor ϵ_c'/ϵ_a' for all compounds.

We may observe from the table the following three properties: (1) The dependence of the anisotropy on the divalent cation radius is similar for the tungstate and molybdate systems; (2) in both systems a maximum in the anisotropy is observed for the strontium compound; and (3) there is an inversion of the anisotropy ratio from <1 to >1 as the divalent cation changes from calcium to those with larger ionic radii. An anisotropy reversal similar to this has been observed in the case of Al_2O_3 and Cr_2O_3[4]. Although the complete optical data for these crystals are not available, it seems reasonable to predict a similar optical anisotropy.

We feel that the relation between the ionic radii and the anisotropy should provide data useful for a theoretical study of these scheelite structures.

We would like to thank A. D. Franklin for his helpful suggestions and E. N. Farabaugh for the x-ray orientation of the crystals.

* The NBS part of this work was supported by the U. S. Atomic Energy Commission.

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Results of Peak Field Measurements for Uniform- and Bi-Periodic Deflecting Cavities

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(Received 6 June 1969; in final form 11 August 1969)

The fast development of superconducting technology seems to make feasible the construction of superconducting rf particle separators which can be used with large proton and electron accelerators. Possible deflectors for such separators are uniform- and bi-periodic disk-loaded structures. In S.C. deflectors the rf-power can be limited either by the peak electric field on the surface (giving rise to heavy field emission), or by the peak magnetic field (causing the quenching of superconductivity).

We introduce the parameters E_p/E_0 and H_p/E_0 (where E_p and H_p are the peak electric and magnetic fields respectively on the deflector surface and E_0 is the equivalent deflecting field) whose knowledge makes it possible to estimate directly the maximum deflection for any given structure and to find the character of this limitation (electric or magnetic.)

It appears to be very difficult to write a computer program which calculates E_p/E_0 and H_p/E_0 for deflecting structures. (Similar for example to the Los Alamos LALA program[1] for accelerating structures.) Simple analytical expressions for E_p/E_0 and H_p/E_0 only exist in the small pitch[2] and in the small hole approximation.[3] Therefore, for the time being, results can only be obtained experimentally by perturbation measurements on models.

We have measured π, $\pi/2$, and bi-periodic cavities with rounded disk openings for a disk thickness $t=10$ mm, and for $\lambda_0=10.5$ cm, $v_p=c$, (λ_0: free space wavelength, v_p: phase velocity). The perturbation method used has been described in detail in Ref. 2. Calibrated Polystirol and metal semispheres of diameters down to 1.2 mm have been used. The frequency measurements were done in copper cavities at room temperature and with an accuracy of ±10–20 Hz. (Typical Q factor: 4000–6000.)

Results for E_p/E_0 and H_p/E_0 and for the boundary conditions shown in Fig. 1 are summarized in Figs. 2 and 3.

The values for $\tilde{a}=0$ are calculated from the small hole approximation. In Figs. 2 and 3 the location of the peak fields is indicated as well. Peak electric field always occurs in the deflection plane ($\theta=0°$), whereas peak magnetic field occurs in the $\theta=90°$ plane. Furthermore, for the $\pi/2$ and bi-periodic cavities, peak fields are always located on the disk side A (see Fig. 1). For sufficiently small openings the peak electric field lies inside the slot region

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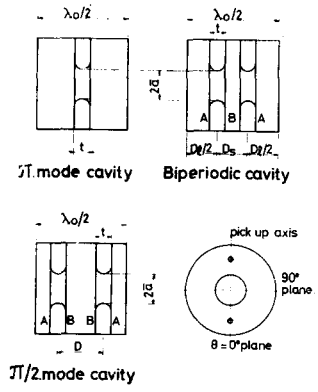

FIG. 1. Geometry of the measured models. $\lambda_0 = 10.5$ cm, $t = 10$ mm, $D = 26.25$ mm, $D_l = 2D_s$.

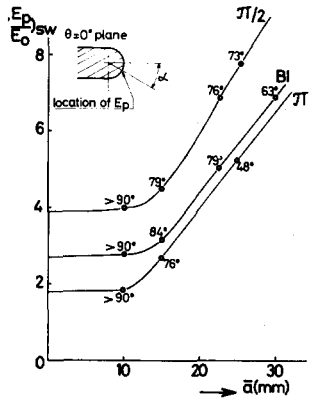

FIG. 2. E_p/E_0 under standing wave condition (sw) as a function of (rounded) disk opening. The location of E_p is indicated by the angle α.

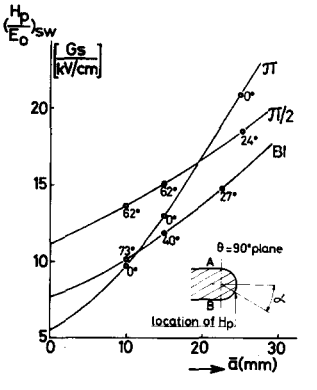

FIG. 3. H_p/E_0 under standing wave condition (sw) as a function of (rounded) disk opening. The location of H_p is indicated by the angle α.

($\alpha > 90°$), and in this case E_p/E_0 nearly doesn't depend on the opening.

By combining these results with the latest results on field limitation in superconducting niobium cavities ($E_p = 400$ kV/cm, $H_p = 600$ G[4]) one finds out that the maximum deflection for all measured models is limited by the peak magnetic field and not by the peak electric field (about a factor 2). Therefore, the reducing of H_p/E_0 will become an important feature in the design of S.C. deflectors.

Measurements on other types of deflecting structures are going on.

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Adhesion of Vitreous Silica to Single-Crystal Gold Using a Recording Microbalance

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In many applications, it is of interest to deposit an adherent layer of metal such as gold on a vitreous substrate. The usual models proposed for the adhesion of a metal to an oxide substrate involve either the formation of a transition layer composed of the oxides of the deposited metal which then interacts with the substrate, or direct interaction of the deposited metal with the surface oxygen ions of the substrate. Since gold forms no bulk oxide, compounds such as bismuth oxide are deposited prior to gold deposition, to provide better nucleation and adherence.[1] It has been found recently that if gold is vacuum deposited in the presence of oxygen,[2] strongly adherent films are formed without the need for intermediate depositions. This effect of oxygen on gold adhesion to silica has also been observed during the solidification of gold on silica substrates.[3] In the absence of oxygen, very little adherence was developed and the gold was easily removed. In the presence of oxygen, strong adherence was observed after solidification, and was localized in the periphery of the drop at the gold–silica–oxygen interface.

The intent of this work was to determine the effect of oxygen on the adherence of silica to gold single crystals of various orientations and to consider various possible mechanisms for the observed effects. Adhesion determinations were carried out at 590°C to permit easily observable effects.

There is uncertainty as to the effect of oxygen on the surface properties of gold. On the basis of zero-creep experiments, it has been concluded that oxygen does not affect the surface energy of gold.[4,5] On the other hand, oxygen adsorption measurements[6,7] and electrical resistivity measurements on thin gold films in oxygen[8,9] indicate a definite surface effect. The possibility that impurities diffusing to the surface of gold at high temperatures may be responsible for anomalies in observed surface structures has been pointed out.[10–12]

It has been assumed in this work that when gold and silica are contacted in the absence of such influences as building vibration and other mechanical interferences, adhesion should be observed for every contact. In the absence of these perturbations, the force required to separate the materials should indicate the extent of interaction. Accepting the fact that elimination of these interfaces is virtually impossible, a different approach was taken. This involved the detection of the presence or absence of adhesion the determinations being made for a large number of contacts. It is felt that an indication of the adhesion tendency of a crystal face could be obtained on the assumption that the more "reactive" face will give a larger number of observed adherence events in a sequence of a given number of contacts and separations. An adhesion experiment consisted of 200 consecutive contacts and separations, and the number of adhesion events per 200 contacts

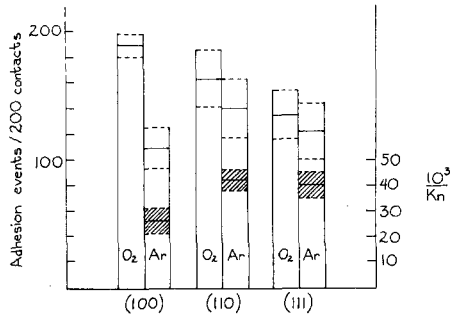

FIG. 1. Adhesion tendencies of single-crystal gold in oxygen and argon. The shaded portions are the reciprocal hardness values (right-hand scale).

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