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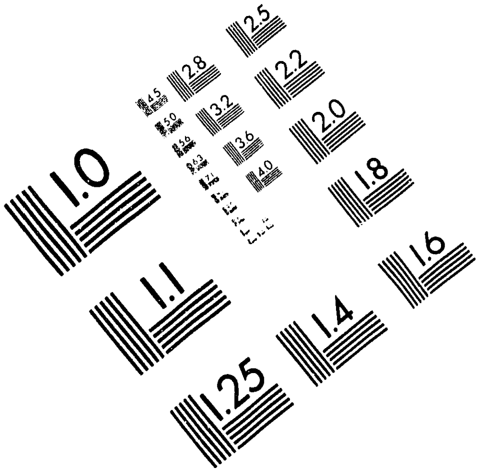

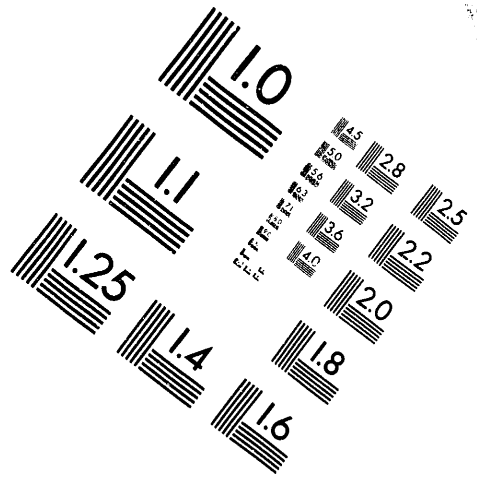

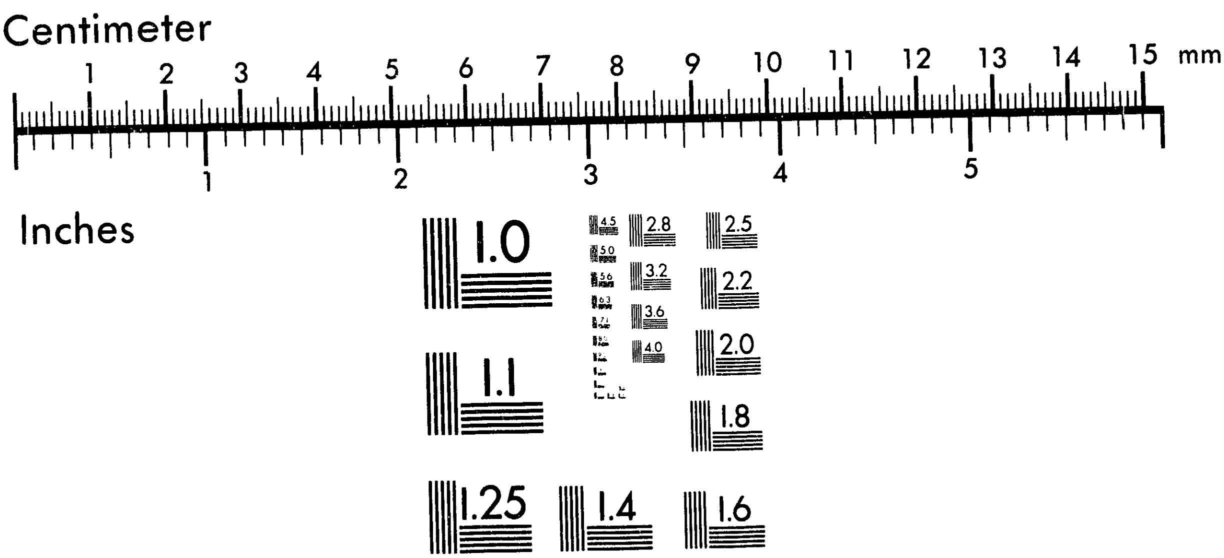

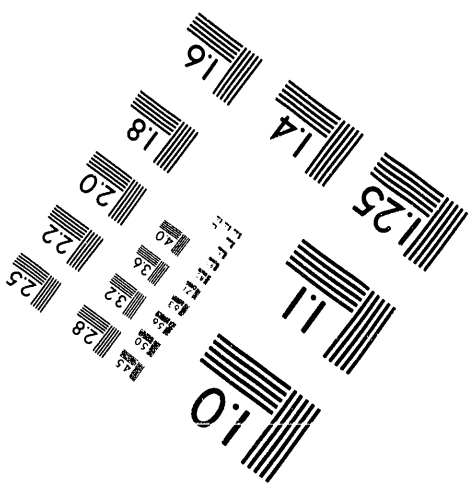

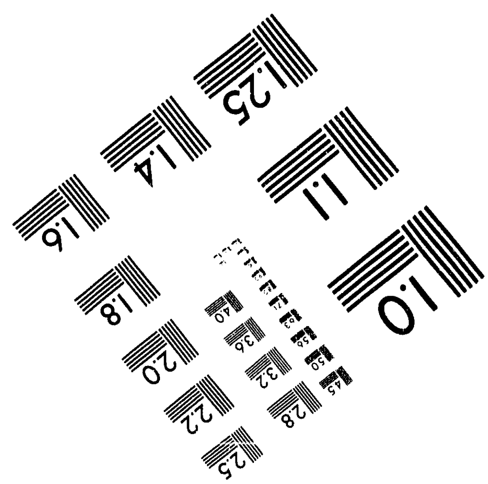

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DESORPTION MEASUREMENTS OF COPPER AND COPPER ALLOYS FOR PEP-II *

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ABSTRACT

PEP-II will be a meson factory circulating asymmetric beams of 9 GeV and 3.1 GeV having maximum currents of 3.0A. Copper beam chambers and absorbers will intercept resulting synchrotron radiation and it is critical that the dynamic gas load from photo stimulated desorption (PSD) and thermal outgassing is below 2 x 10^{-6} molecules per photon. An experiment was set up to measure PSD from 1m long bar samples and a chamber sample, fabricated from selected copper and copper alloys then exposed to white light with a critical energy of 500 eV, on beamline U10B at the VUV ring of the National Synchrotron Light Source (NSLS). Based on U10B results a prototype chamber was built and will be exposed to white light with higher critical energies of up to 5 KeV, on

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beamline X-28A at the X-ray Ring of the NSLS. This paper presents the measurements of H_2, CO, CO_2 and CH_4 desorption yields as function of accumulated photon flux, angle of incidence, sample material, and surface condition. The results are compared with that of previous work on similar materials and with that of others for copper.

I. INTRODUCTION

The PEP-II B meson factory is designed to store asymmetric beams of 9 GeV and 3.1 GeV at maximum design currents and its vacuum system presents a technical challenge beyond that of any existing electron-positron collider. The gas load produced by stored electrons in the high energy ring (HER) will be determined by photon stimulated desorption (PSD) from surfaces in beam bending chambers. Desorption and accompanying heat dissipation are critical parameters in the selection of the material and in the design of the beam chambers.

Copper is the preferred material for the B Factory HER since it is fully self-shielding for radiation and has excellent thermal conductivity. In this study, we show that an acceptably low PSD with a desorption coefficient of 2×10^{-6} molecules per photon is achievable. A collaborative test program has been established between Lawrence Livermore National Laboratory (LLNL) and the National Synchrotron Light Source (NSLS) to study various copper materials proposed for the vacuum chambers to accertain good structural properties of Cu chambers.

II. EXPERIMENT

One meter long sample bars of copper and copper alloys were measured in the set up previously described [2,3]. Samples of different materials from vendors were prepared at LLNL and shipped to NSLS for measurements. Each sample was installed and vacuum baked at 200°C for 48 hours prior to the PSD and electrical measurement runs. One sample bar was glow discharge conditioned. A test chamber was fabricated using one of the copper materials based on sample measurements. The copper chamber was first measured after vacuum bake, then it was argon glow conditioned, rotated to a different surface and vented with nitrogen. Both ends were left open for several days exposure to atmosphere, then closed, vacuum baked, and then remeasured.

With the exception of one sample run at 25 mrad all the other samples and the copper chamber were run at 100 mrad incident angle. The white photon beam has an opening aperture of 10 mrad horizontally and 3.8 mrad vertically yielding a cut off energy (FWHM) of 22 eV. Photo electron yields, absorbed photons, and reflected photons were measured using variable DC voltage supplies connected to a pick up wire and a copper end plate.

The conductance was measured and the pick up wire, end plate, and residual gas analyzer (RGA) were calibrated in-situ. Pressure rises ($\Delta P/I$) for the principle desorbed gases are obtained from the BAG and RGA readings and the respective yields in molecules per photon are calculated.[4] Total photon flux is used in the calculations. In addition to PSD measurements, periodic photon and photo electron measurements are made using the wire and end plate photon stop.

The Hitachi C10100 sample was argon glow conditioned after a photon dose of 3 x 10^{23} photons. Photo micrographs of the measured sample surfaces were made. To explain differences in PSD and photo-electric currents, a three meter B-factory prototype chamber has been built from the selected material and cross section and will be exposed to photon flux with higher critical energy at x-ray beamline X28A at the NSLS.

III. RESULTS AND SUMMARY

Results from normal incidence photon measurements on the copper beam stop were identical to those previously reported[2]. Fig. 1 shows the results for pure copper after vacuum bake and after in-situ argon glow conditioning. Figs. 2 - 6 show some results for copper and copper alloys after vacuum bake.

Since the low dose points are difficult to measure an accurate comparison can be made after an accumulation of 1 x 10^{22} photons. From Figs. 1 to 6 we make the following observations at a dose of 3 x 10^{23} photons.

(1) The C10700 copper alloy yield, η, is the largest of the runs for H_2 and CO.

(2) The samples with machined surfaces (C10100 + C15715), yield the smallest η for H_2, CO, and CH_4.

(3) The C15715 machined glidcop surface yields the lowest η for CO_2. The CO_2 yield for other materials are at least a factor of three higher and are within a factor of two of each other. After 10^{23} photons per meter, the dispersion sample (C15715) had the same yield for H_2, CO, and CH_4 as the machined vacuum melt-copper (C10100) (Run #1).

(4) The H_2, CO, CO_2, and CH_4 yields for all C10100 and C10300 copper materials are within a factor of two of each other.

(5) The desorption yields for the copper chamber are within a factor of two agreement of the C10100 and C10300 factory sample results.

Photo-electron yields on the copper stop for normal incidence photons were the same as those previously reported.[2] Photo-electric currents for the samples and chamber were measured and are summarized in table 1. The percent (%) of reflected photons on the stop after bake or glow is indicated. The following is noted:

(1) Photo-electron yields are lower in the chamber after GDC as was found with previous materials.[2]

(2) Photo-electron yields are lowest on the beam stop from machined samples and corresponding photo micrographs show machine cuts to be perpendicular to the photon beam.

(3) The C10700 sample and the chamber produced the highest yields at 100 mrad incidence. Photo micrographs show draw grooves in line with the beam. That sample also has the highest photo-electron yield on the stop.

(4) The C10100 sample from vendor (1) yields twice the amount of reflected photons from the factory finish as from the machined finish and the micrographs show a much smoother factory finish.

Finally, it is instructive to compare our results in Fig. 6 with those obtained at DCI[6] for two different OFHC coppers as listed in Table II. Despite many different quantities, i.e. beam current, photon beam dose, BA gauge, and RGA calibrations at two different photon energy ranges and at two different labs, the agreement is excellent.

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FIGURE LEGENDS

Fig. 1. Molecular desorption yields and total gas desorbed for Machined Finish Hitachi C10100 copper after bake (Run 1) and after argon glow discharge conditioning (Run 2).

Fig. 2. Molecular desorption yields and total gas desorbed for Machined Finish Glidcop C15715 copper composite after bake (Run 3).

Fig. 3. Molecular desorption yields and total gas desorbed for Factory Finish Kabel Metal C10100 copper after bake (Run 5).

Fig. 4. Molecular desorption yields and total gas desorbed for Factory Finish Kabel Metal C10300 copper after bake (Run 7).

Fig. 5. Molecular desorption yields and total gas desorbed for Factory Finish Wolverine C10700 copper alloy after bake (Run 9).

Fig. 6. Molecular desorption yields and total gas desorbed for a Factory Finish Hitachi C101000 copper chamber after bake (Run 1).

TABLE I

SAMPLE BAR AND BEAM STOP PHOTOCURRENTS IN μA/mA

		Sample		Beam Stop				Diffuse Reflection		Surface
Run	Material (vendor)	B	GDC	B	B (%)	GDC	GDC (%)	B	GDC	Finish
1,2	C10100 (1)	5.1	-	0.06	1.2	-	-	0.2	-	Machined
3	C15715 (2)	2.9	-	0.05	1.7	-	-	0.01	-	Machined
5	C10100 (3)	7.2	-	0.14	1.9	-	-	0.45	-	Factory
7	C10300 (3)	4.6	-	0.11	2.3	-	-	0.2	-	Factory
9	C10700 (4)	7.8	-	0.55	6.6	-	-	0.4	-	Factory
31	C10100 (3) 25mr	3.6	-	0.08	2.2	-	-	0.006	-	Factory
13	C10100 (1)	4.1	-	0.11	2.6	-	-	0.1	-	Factory
1,2	CHAMBER	8.5	5.3	0.41	4.6	0.34	6.0	0.4	0.1	Factory

TABLE II

COMPARISON OF OFHC COPPER CHAMBER RESULTS

	BNL	DCI	DCI/BNL Scaling Ratio
Critical energy (eV)	500	3750	
Angle of incidence[1] (mr)	100	11	2
Vertical opening angle (mr)	3.8	5	0.85
Photon flux < 10eV	0.32	0.17	0.81
Energy correction[2]			~1.5
Total Scaling Ratio			2
η at 2×10^{23} ph/m			**Measured Ratio**
H_2	2×10^{-5}	2×10^{-5}	1
CO	6×10^{-6}	6×10^{-6}	1
CO_2	4×10^{-4}	8×10^{-6}	2

[1] Fig. 11 in Ref. 4.

[2] Obtained on the x-ray ring[7].

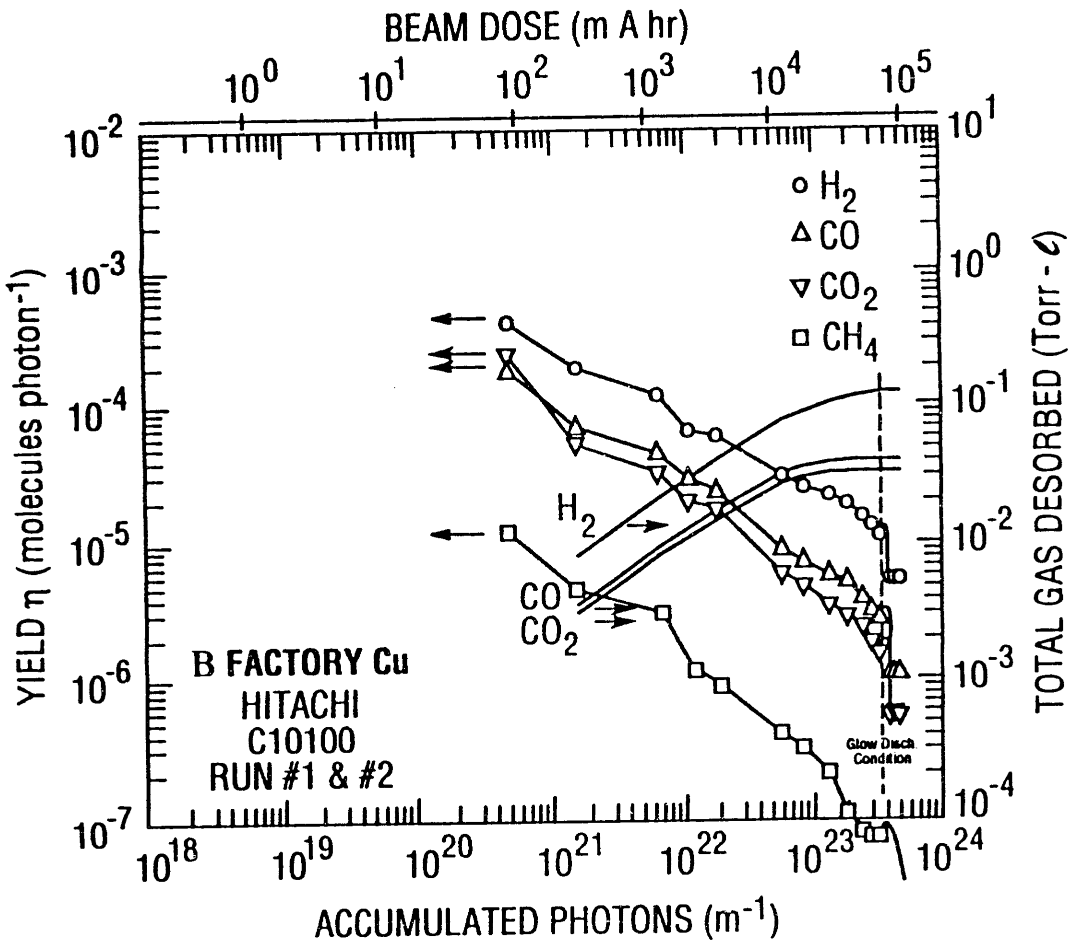

FIG. 1

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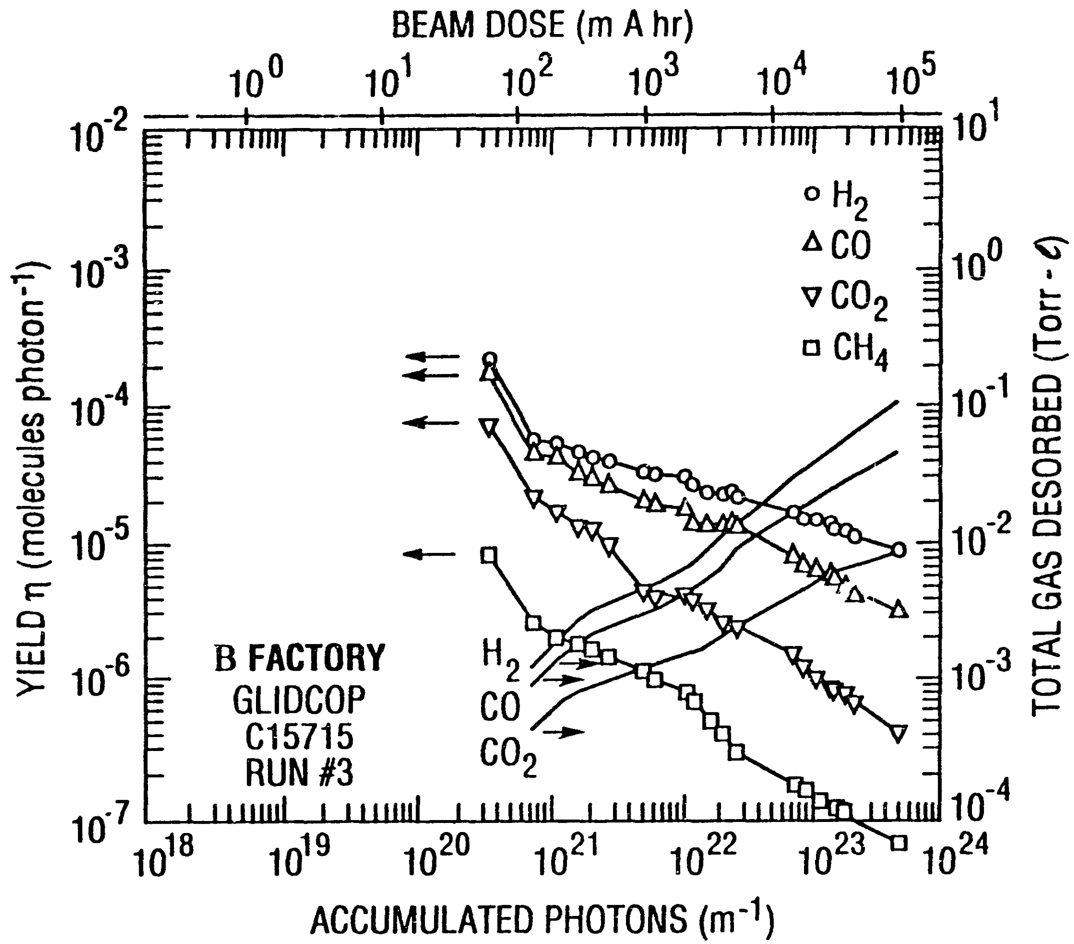

FIG. 2

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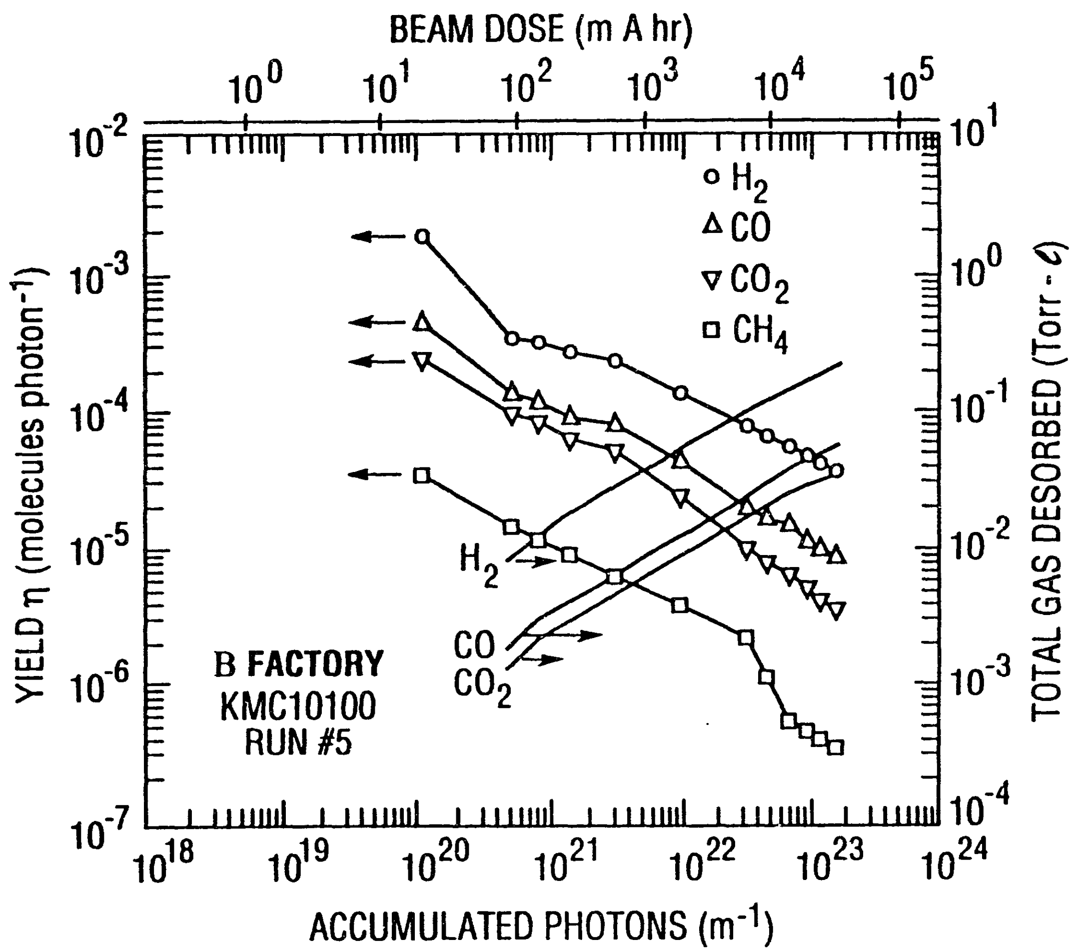

FIG 3

Foerster 6a 6/17/92 judy

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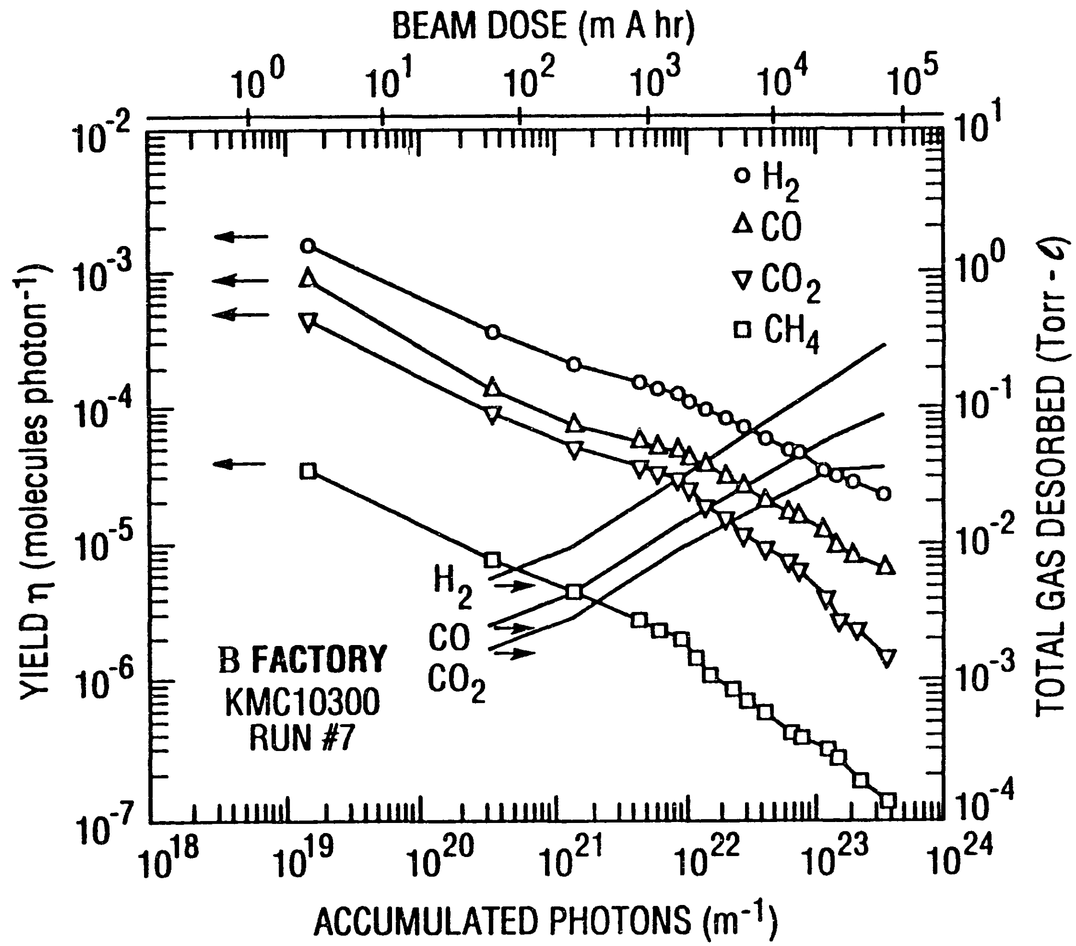

Fig. 4

Foerster 3a 6/17/92 judy

VS1-THAS 361

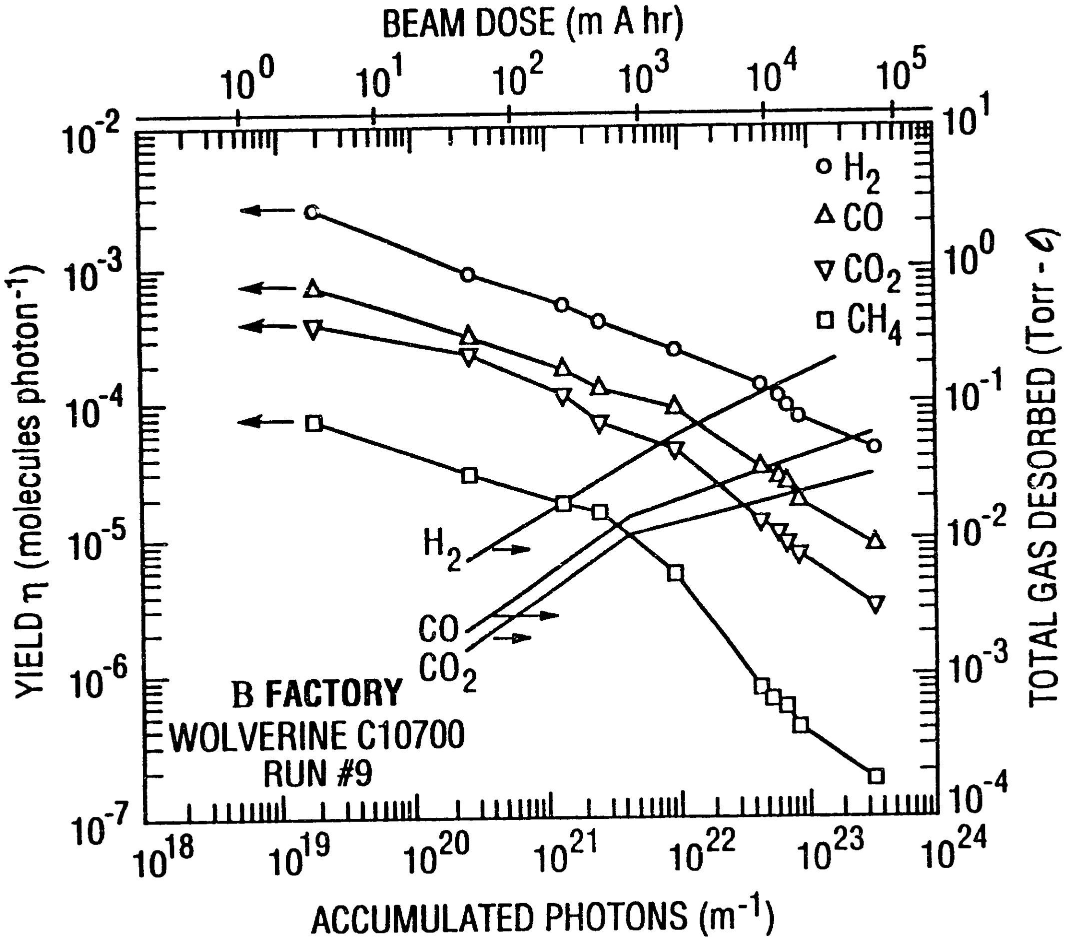

Fig 5

Foerster 7a 6/17/92 judy

VS1-THA5 361

FIG 6
VSI-TIIAS
Foerster 12a 6/17/92 judy
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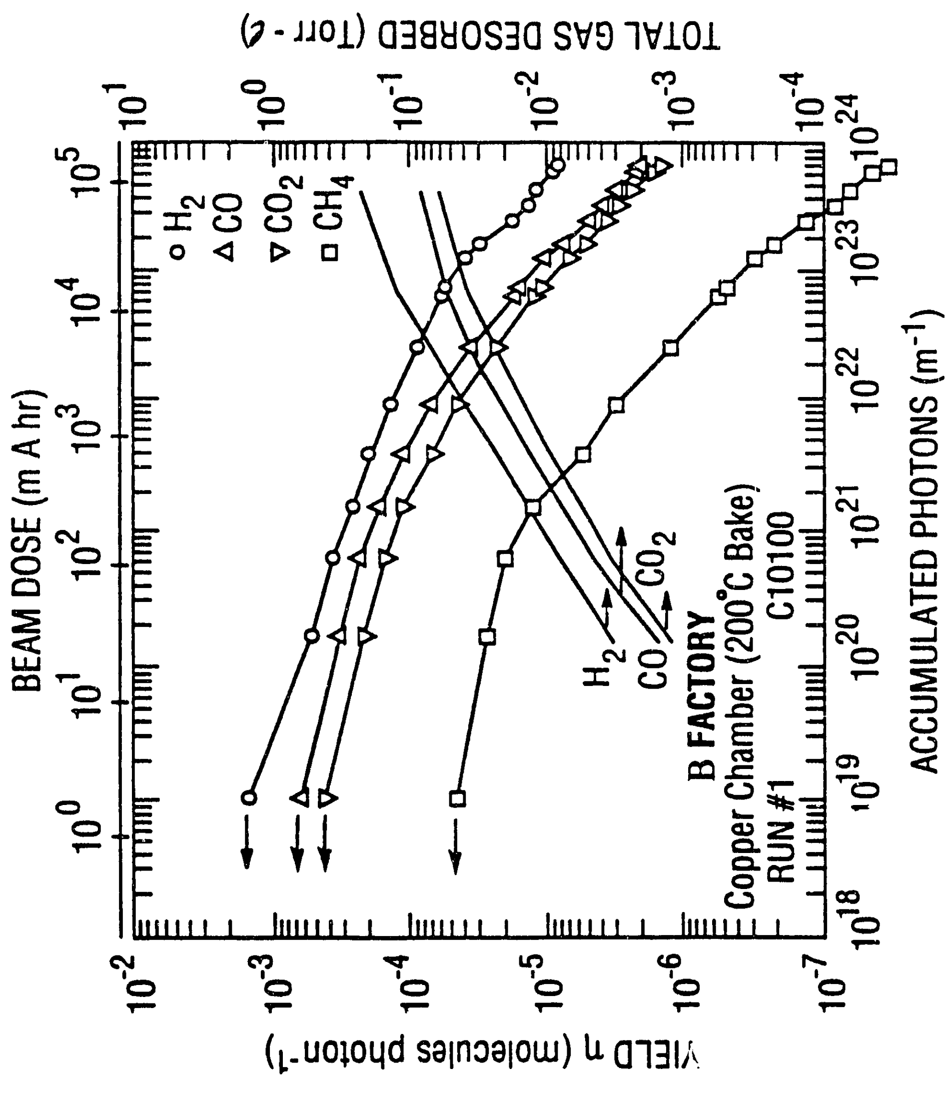

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