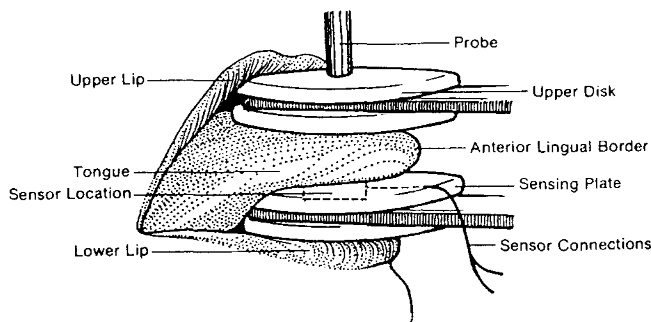


FIG. 2. Tongue positioned in clamp ready for measurement.

TABLE I. Means and standard deviations of lingual vibrotactile thresholds, presented in microns of displacement, for five lingual pressures ($n = 8$).

| PSIA | 300 Hz M | SD |
|---|---|---|
| 02 | 1.89 | 0.87 |
| 05 | 1.68 | 0.58 |
| 08 | 0.99 | 0.41 |
| 11 | 1.72 | 0.68 |
| 14 | 2.10 | 0.90 |

The mean of three trials, using an ascending method of limits, was considered threshold for each experimental condition.

Table I presents mean thresholds and standard deviations for each pressure condition. It may be seen that thresholds decreased as pressure increased to 8 psia. Above 8 psia, thresholds increased. Not all pressure conditions were significantly different from one another. However, thresholds at 8 psia were significantly different ($p = 0.05$) from thresholds at any other pressure.

These data suggest that failure to control clamp pressure could result in variable measurement data. The data further suggest that 8 psia may be the most suitable choice for tongue pressure measurements. This pressure appears to yield maximally enhanced thresholds and may avoid neural masking which might occur at higher pressures.

The pressure sensing plate described would enable investigators to control clamp pressure during vibrotactile measurements. These controls would ensure more accurate and stable measurements and would permit more objective data comparisons across studies.


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# Simple multi-spark-gap tracer for Z-pinch experiments


B. Arad[a] and E. Ruden

*Department of Physics, University of California, Irvine, California 92717*



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A simple inexpensive device has been constructed which enables us to know whether all the spark gaps fired simultaneously or what spark gap fired late and by how much it was delayed.


In a medium energy Z-pinch device—like the one located on this campus[1,2]—one charges several capacitors and discharges them simultaneously into the transmission line. This discharging is carried out by activating the spark gaps separating the capacitors from the transmission line. A very much delayed firing of one or more spark gaps sometimes can be traced on the $\dot{B}$ curve (Fig. 1). In many cases, the delay is much smaller and will not be observed, affecting, however, the outcome and causing the results to lose their reproducibility. In order to overcome this problem we have built a simple device. This device traces all the spark gaps simultaneously, telling us what data to reject. Furthermore, it helps to trace malfunctioning spark gaps which need to be replaced.

It has been suggested before[3,4] to observe the light emitted by the spark gaps with optical fibers and direct the other end of those fibers to a streak camera. The streak camera solution has the advangage of a 1-GHz bandwidth (which is not necessary for spark-gap observations) and of being able to observe many more spark gaps simultaneously. However, it has a clear disadvantage of price. It is expensive, not always available in the lab and when available, it is usually tied up to other experiments. The solution we are presenting here needs an oscilloscope with a bandwidth around 100 MHz and a polaroid camera. Both these items are relatively inexpensive and are practically available in any laboratory.

When a spark gap is activated, it emits a large amount of light. A part of this light is collected by a 7-$\mu$m-diam quartz




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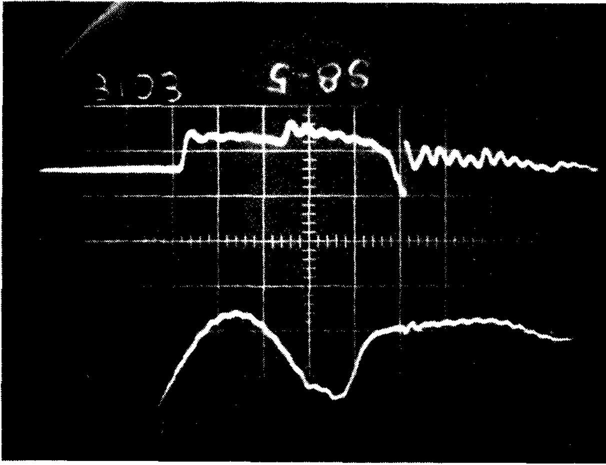


FIG. 1. A $\dot{B}$ trace. The jump due to a very late firing of one or more spark gaps is indicated by an arrow. The horizontal scale is 200 ns/div.

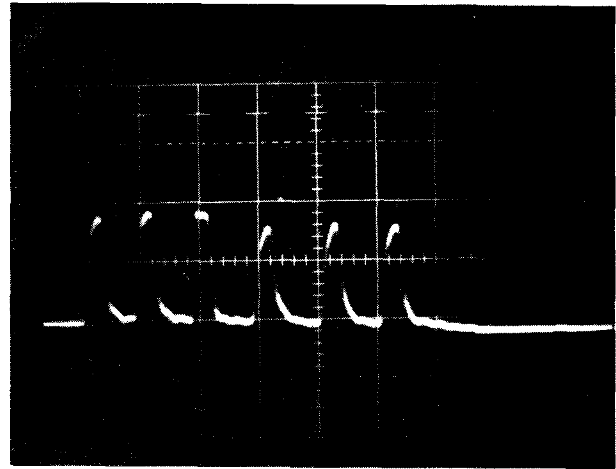


FIG. 3. An oscilloscope trace of all the spark gaps firing simultaneously. The time scale is 100 ns/div.

fiber and transmitted to the screen room (Faraday cage) to a 931 A photomultiplier tube. The P.M. tube signal drives a monostable multivibrator having a pulse width of 100 ns (see Fig. 2). The positive output of this monostable m.v. is differentiated, using the negative part to drive a second monostable m.v. having a constant width of 30 ns. All the 30-ns pulses are added together and sent via an emitter follower to an oscilloscope.

The width of the first monostable m.v. is dictated by $i$, the sequential number of the spark gap it represents. In our case, having six spark gaps, this width will vary from 100 ns for the first one and up to 600 ns for the sixth one. These variations cause the 30-ns pulse of the second monostable m.v. to vary in time accordingly and when added together it results in a series of six 30-ns pulses, the leading edge of which is separated by 100 ns (Fig. 3). Should a single spark gap fire late, its corresponding 30-ns pulse will be shifted from its original position and even a 20-ns delay can easily be observed (Fig. 4).

To sum up, we have described here a multi-spark-gap tracer which is useful in order to objectively reject inappropriate data. Such a device can be helpful whenever the simultaneity of several events, optical or electrical, has to be known to within 10 ns. This device is inexpensive, simple, and easy to assemble.

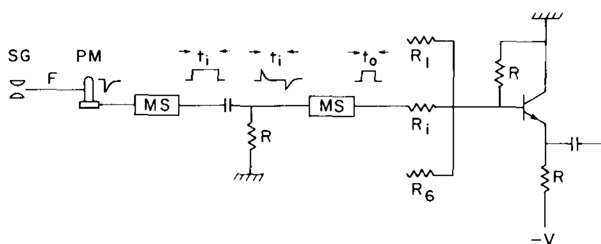
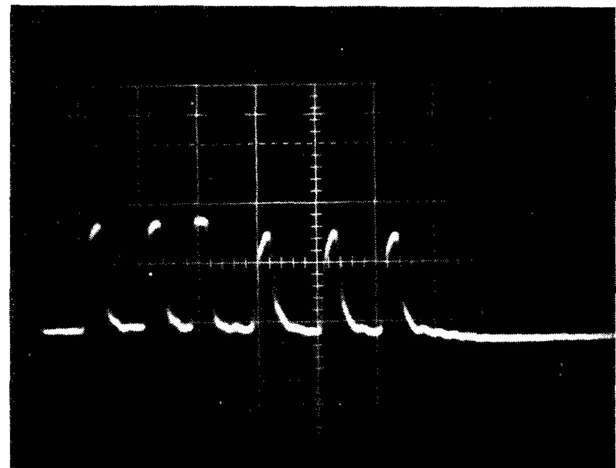
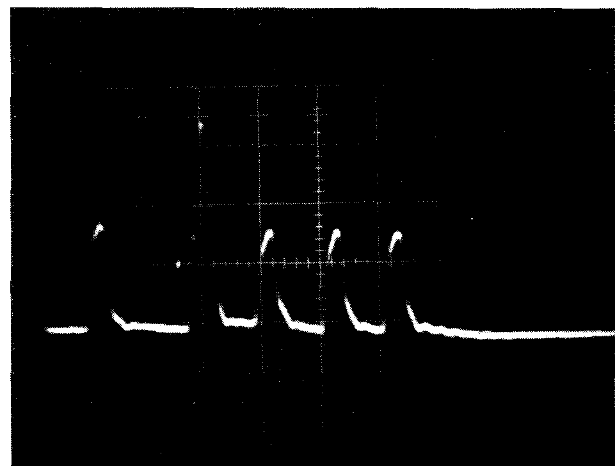



FIG. 2. The schematic layout of the device. SG—sparkgap, F—a 7-$\mu$m-diam quartz fiber, PM—931A photomultiplier tube, MS—monostable multivibrator (Motorala MC 10198), $t_i = 100\,xi$ ns, $t_o \sim 30$ ns, and all the $R$ values are 50 $\Omega$.



(a)



(b)

FIG. 4. An oscilloscope trace in which the second signal was purposely delayed (a) by 15 ns (b) by 80 ns. The time scale is 100 ns/div.



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[a] On leave from the Department of Plasma Physics, Soreq Nuclear Research Center, Yavne 70600, Israel.

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# Preparation of self-supporting Si thin single crystals by solid phase epitaxy and selective etching

Hiroshi Ishiwara and Masahiro Fujii

*Graduate School of Science and Engineering, Tokyo Institute of Technology, 4259 Nagatsuda, Midoriku, Yokohama 227, Japan*

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A novel technique to prepare self-supporting single-crystalline Si films with submicron thicknesses is presented, in which their thicknesses are determined by those of amorphous Si films deposited on Si substrates. In the preparation Boron ions are implanted near the interface between the film and the substrate, the film is then epitaxially grown in solid phase by furnace annealing, and finally, the substrate is selectively etched. It was found that the thickness uniformity and crystalline quality of the films were rather good over an area of 3 mm in diameter.

Preparation of self-supporting single-crystal Si films with submicron thicknesses has become important in such device technologies as x-ray and ion-beam lithographies, as well as in material studies using electron or ion beam probes. Cheung has reported a fabrication procedure[1] of the films using diffusion of B atoms and etching by ethylendiamine–pyrocatechol (EDP), which is known not to attack Si layers with B concentration higher than $7\times10^{19}$ cm$^{-3}$ (Ref. 2). However, in order to precisely control the film thickness over a large area, the thermal diffusion or the usual ion implantation techniques may not be sufficient in uniformity and reproducibility. In this note, we report a novel method to prepare self-supporting Si thin crystals, in which their thicknesses are determined by those of amorphous Si films deposited on single-crystal Si substrates rather than the implantation conditions of B ions. That is, in this method B ions are implanted near the interface between the deposited amorphous film and the Si substrate to doses around $3\times10^{15}$ cm$^{-2}$ and the film is epitaxially grown in an electric furnace at temperatures around 650°C. It has been known that the electrical activity of B atoms incorporated in the epitaxially grown film is very high even at 650°C, while that the activity of B atoms in crystalline Si is less than a few percent in these dose and temperature ranges.[3,4] So, we can expect that the EDP etching from the backside reproducibly stops at the interface between the epitaxial fim and the substrate, where the carrier concentration is abruptly changed.

The experimental procedure is as follows: *N*-type Si(100) wafers were boiled in so-called RCA solution. Samples were then loaded in a vacuum chamber and preheated at 900°C for 30 min. Amorphous Si films about 400-nm thick were deposited at room temperature using an electron gun and they were post-heated in the same vacuum at 400°C for 1 h in order to decrease void density in the deposited film.[5] Then, B ions were implanted so that the average projected range $R_P$ of the ions was roughly equal to the amorphous film thickness, and the peak concentration well exceeded the value of $7\times10^{19}$ cm$^{-3}$. In our experiment, the respective values of 144 keV ($R_P = 408$ nm) and $3.1\times10^{15}$ cm$^{-2}$ (the peak concentration $= 1.5\times10^{20}$ cm$^{-3}$) were used. In order to minimize the etching from the surface, the carrier concentration near the surface was also increased by implanting 40-keV B ions to a dose of $2.2\times10^{15}$ cm$^{-2}$. Solid phase epitaxial

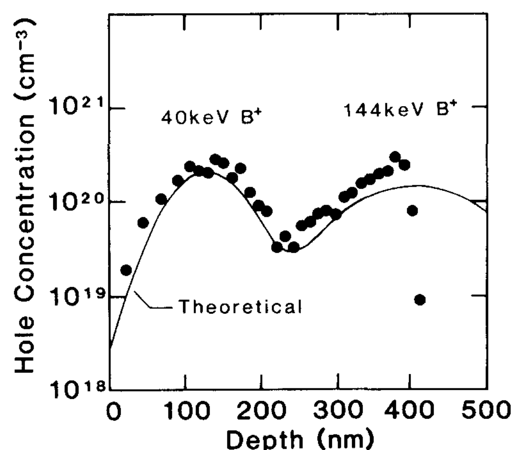


FIG. 1. A carrier profile in B-implanted Si. 144-keV B ions were implanted near the amorphous–crystalline interface at a depth of 400 nm to a dose of $3.1\times10^{15}$ cm$^{-2}$, while 40-keV B ions were implanted in the amorphous Si to $2.2\times10^{15}$ cm$^{-2}$.

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