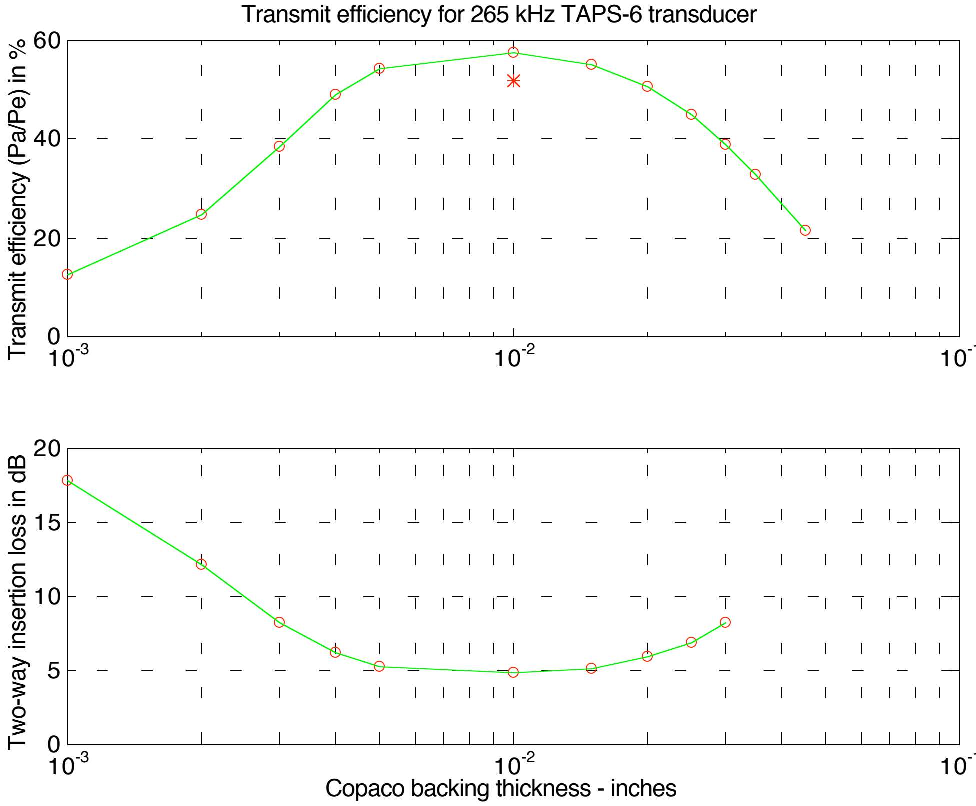
TAPS-6 TRANSDUCER DESIGN
OCT 1997

The TAPS transducers are all basically similar in design. Each element is a Navy Type III ceramic element, housed in an anodized 6061-T6 aluminum housing (see assembly drawing, Fig 1). The ceramic was selected on the basis of insensitivity to changes in pressure and temperature, so that system sensitivity will be unaffected by changes in depth or water temperature.

Backings are COPACO, a compressed paper-mylar material, used as a transformer between the element and the aluminum backing. The windows are cast from epoxy resin (Castall EFR-342 with RT-7 hardener), selected both for desirable acoustic properties and a coefficient of thermal expansion matched to that of the aluminum housing.

Theory suggests that optimal efficiency will be obtained when the acoustic window and the back matching layer are both 1/4 wavelength. To check this, estimates of the expected transmit efficiency and insertion loss were made using PiezoCad® with the backing thickness as a free parameter. Window thickness was allowed to vary as the transducer cavity depth is fixed. For the 265 kHz transducer, the following results were obtained:

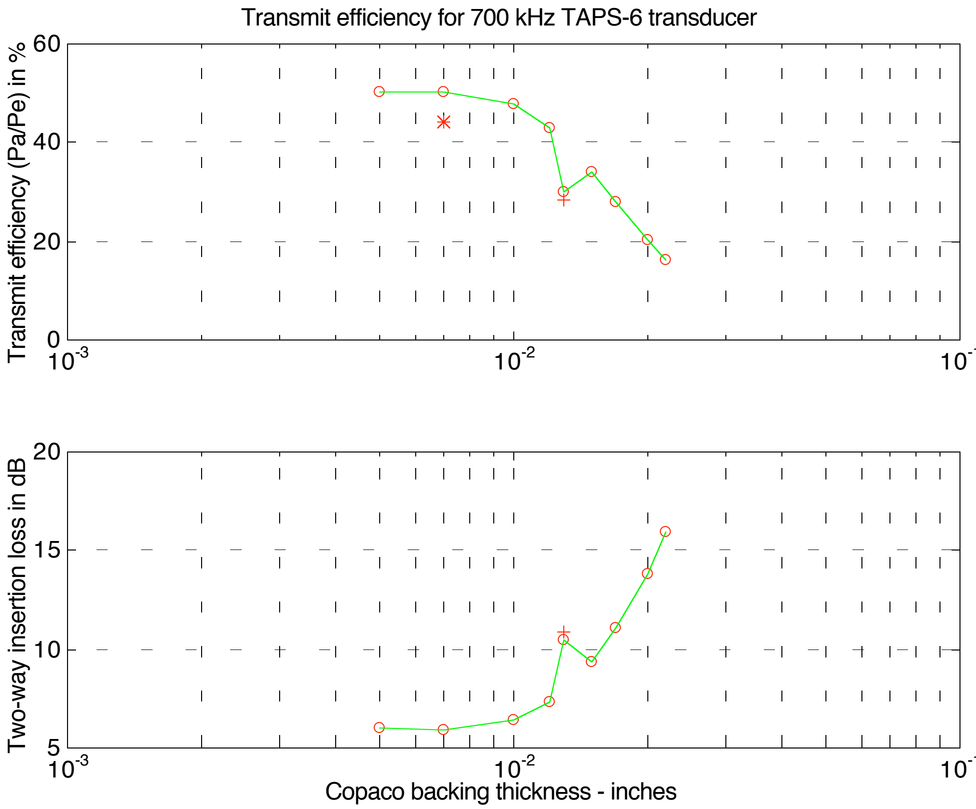


Interestingly, maximum predicted transmit efficiency occurs at a backing thickness of 0.010" and not at 0.035" (λ/4). A minimum of insertion loss also occurs at this point. Window thickness would be about .130" (λ/4 is .104")

A transducer was built using a .010" COPACO backing and the transmit efficiency measured. This value, 52%, is shown on the figure as a *. The assembled transducer matches predictions well within experimental uncertainty.

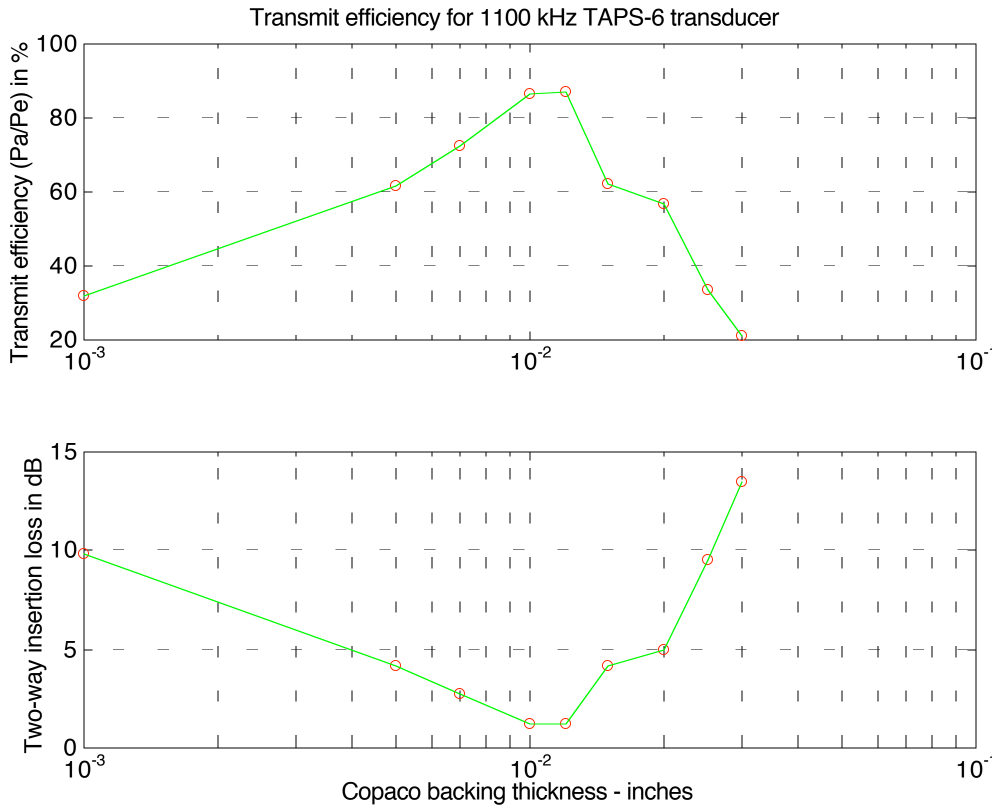
Similar predictions were run for the 420 kHz transducer. Maximal efficiency was predicted for backing thicknesses of 0.010" and below; a value of 0.010" was selected. Window thickness would be about 0.079" (λ/4 is .066"). Measured efficiency for the prototype was 58% compared to 52.4% predicted. This discrepancy is within the expected accuracy of the measurements.

Similar predictions were run for the 700 kHz transducer. Maximal efficiency was predicted for backing thicknesses of 0.010" and below; a value of 0.007" was selected. Window thickness would be about 0.049" (λ/4 is .039"). Measured efficiency for the prototype was 44% compared to 50.4% predicted. This discrepancy is within the expected accuracy of the measurements.

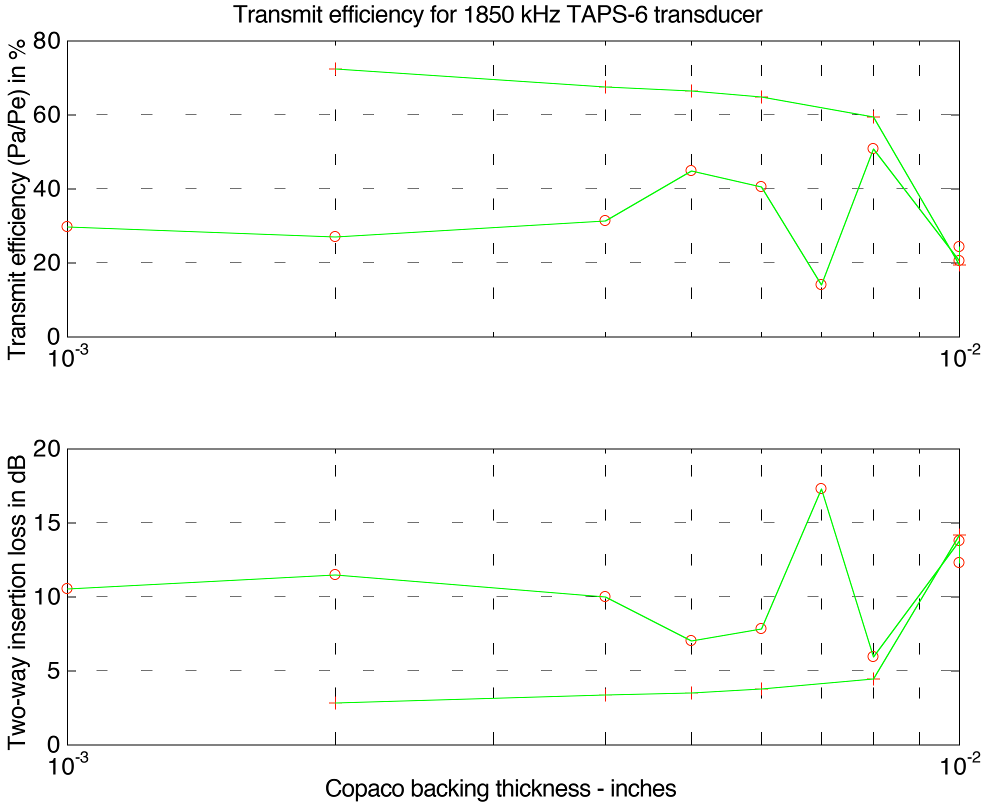


The three high-frequency transducers are gaussian-spot elements--one electrode is full-sized and the other is of reduced diameter to provide a gaussian-like electrical field in the element and a gaussian acoustic pattern. This configuration cannot be modelled by the 1-D Mason model of PiezoCad, so simulations were made assuming full-electrode elements with dimensions identical to the actual elements. It is presumed that transmit efficiencies will be substantially lower than predicted.

Predicted efficiency for the 1100 kHz element is shown below. Maximum efficiency is predicted for a backing thickness of around 0.010” ($\lambda/4$ is .0083”). The predicted value, 86.5%, is probably highly unrealistic.

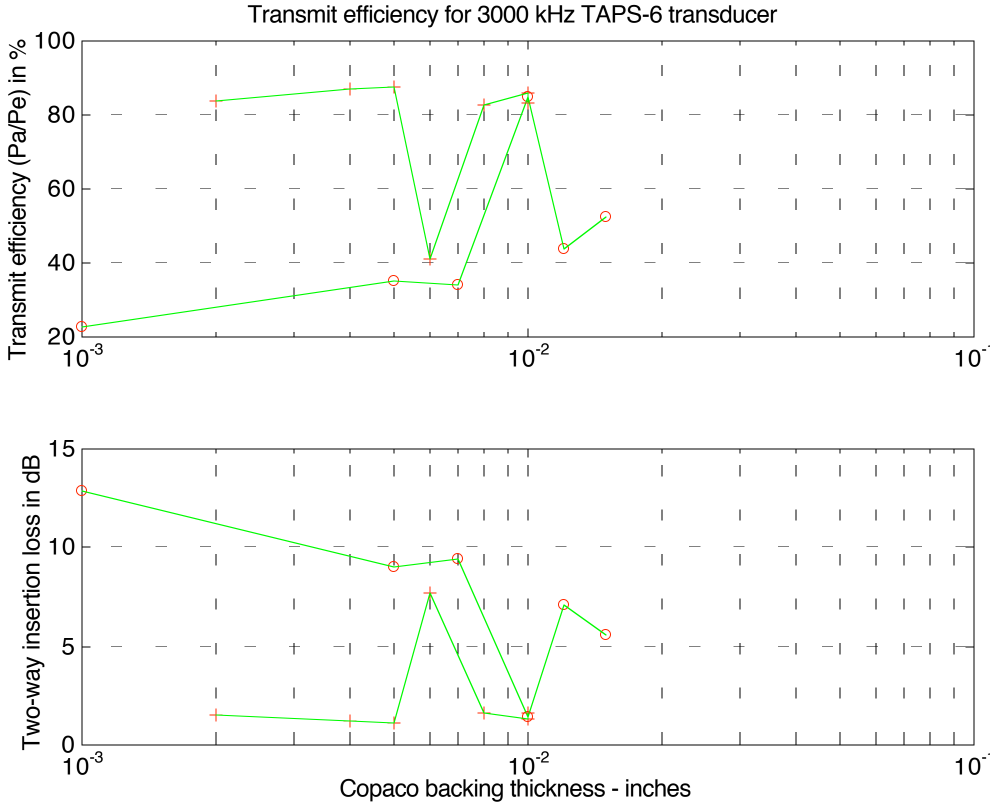


Predicted efficiency for the 1850 kHz transducer is shown below. The circles represent data where the window thickness is allowed to vary as the backing thickness changes (λ/4 is .005”). Considerable variation occurs as the backing (and window) thickness changes.The crosses denote predictions where the backing is glued to brass shim stock of the correct thickness to maintain the epoxy window at λ/4 (0.015”). Efficiency is maximal for thin backings, as found previously.



A backing thickness of 0.005" on a sandwich of .006-.007" of brass was selected for the prototype transducer. Assembled window thickness would be 0.015".

Similar predictions were obtained for the 3 Mhz transducer. The plot is similar to that for 1850 kHz. In this case, the backing is $\lambda/4$ at .003" (thinner than available COPACO materials) and the window is $\lambda/4$ at .0092".



It is interesting to note that efficiency is nearly maximal and insertion loss is minimal for a backing thickness of 0.010" (ca. one wavelength) where no brass shims are required to obtain $\lambda/4$ window thickness.