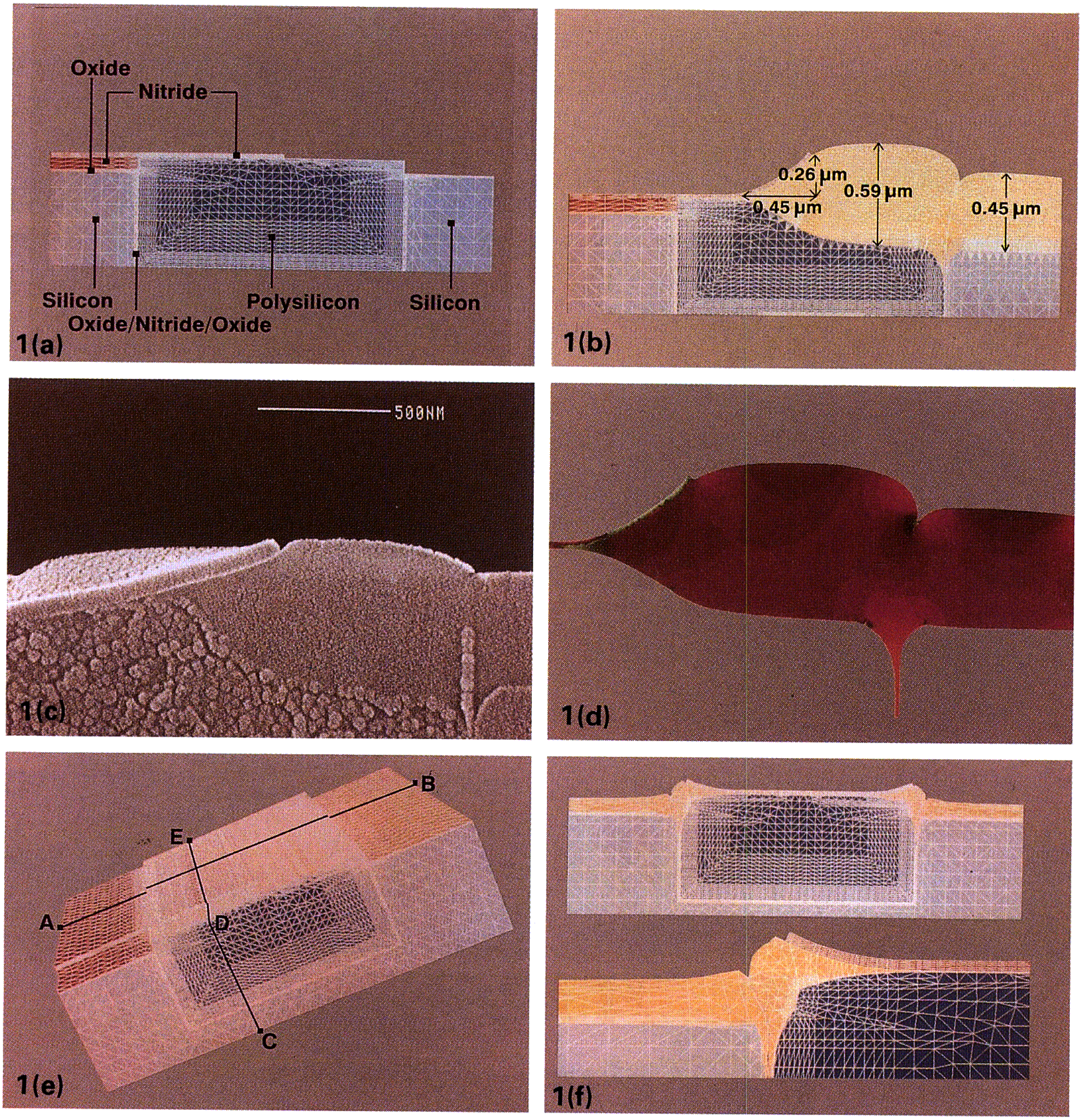
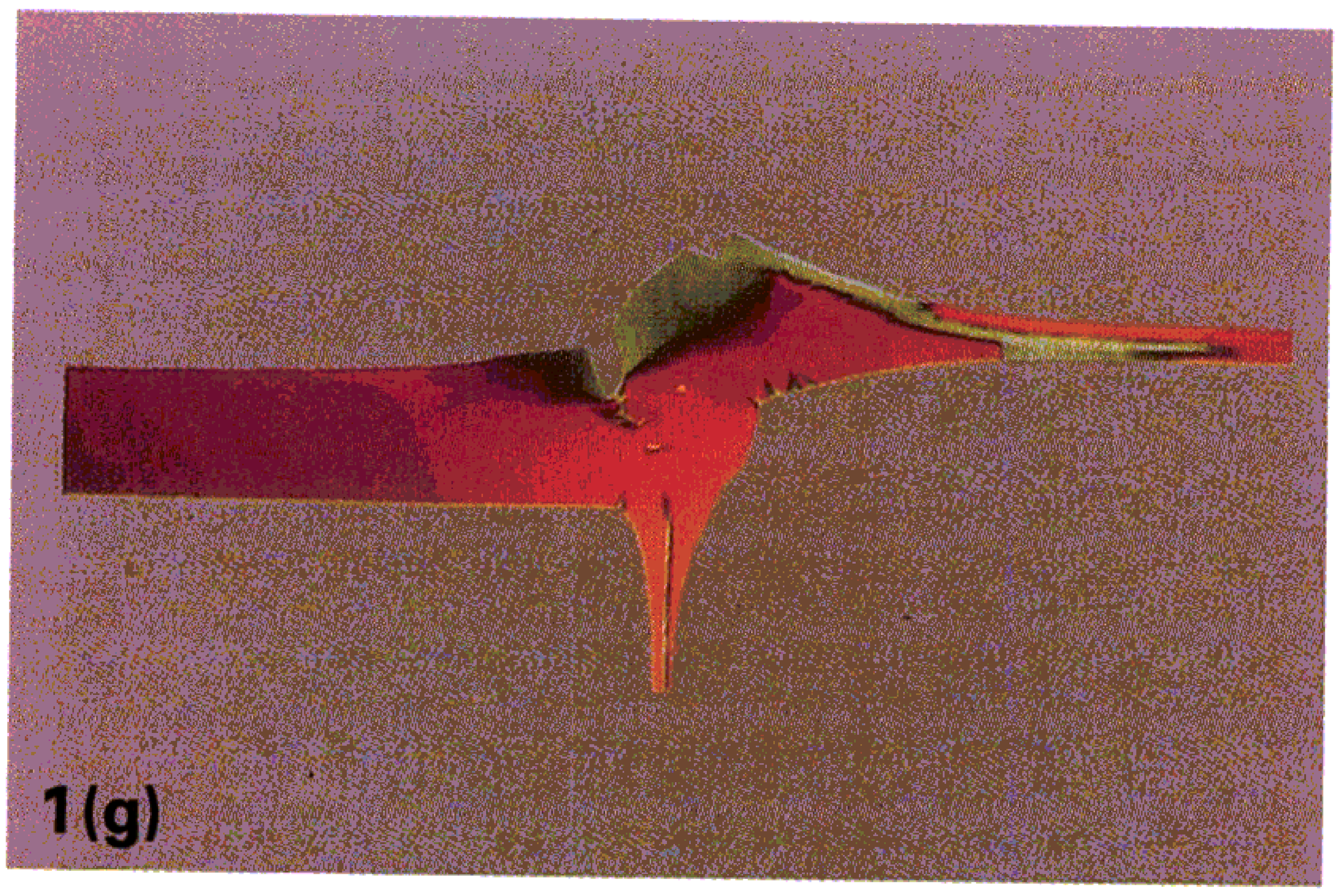
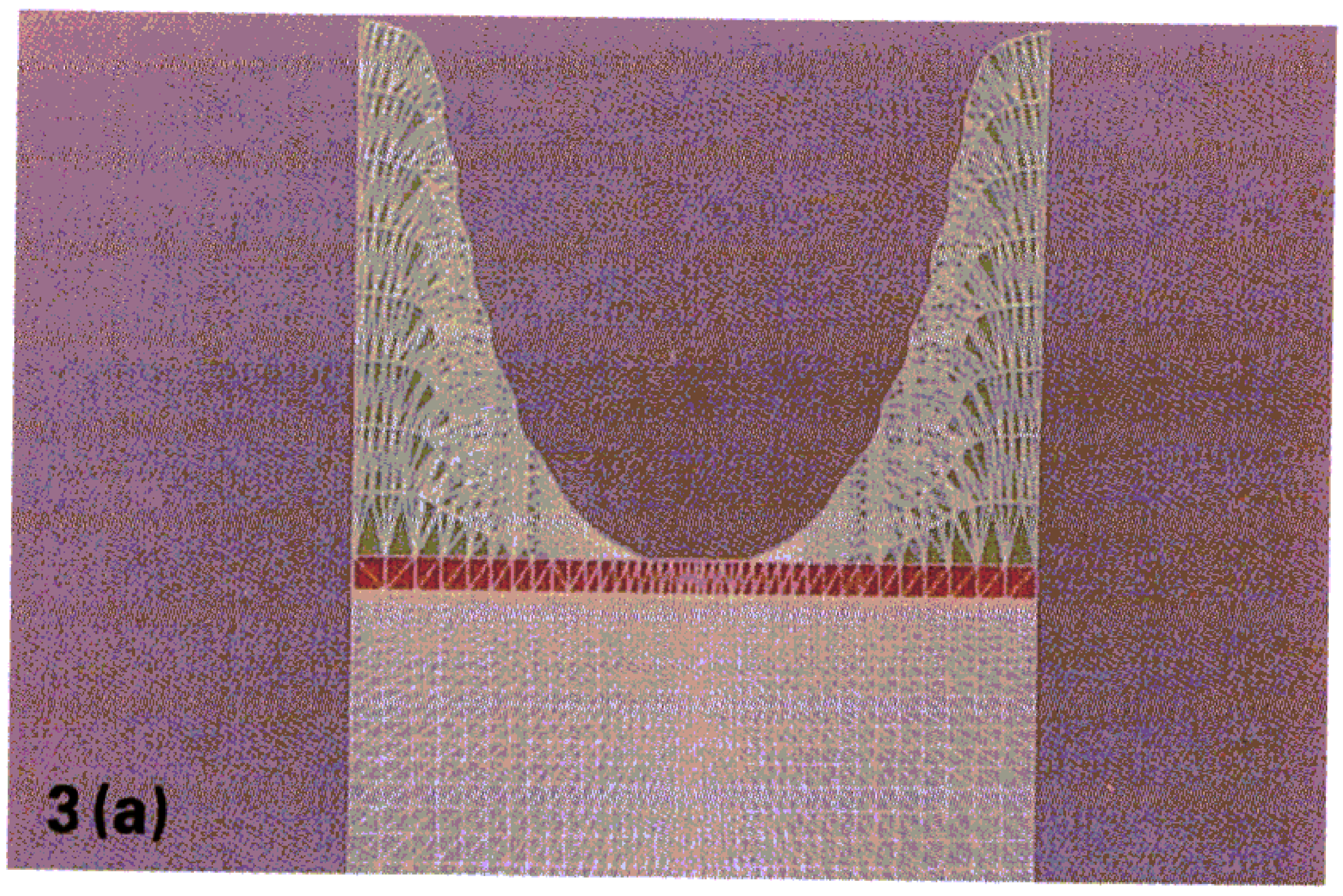
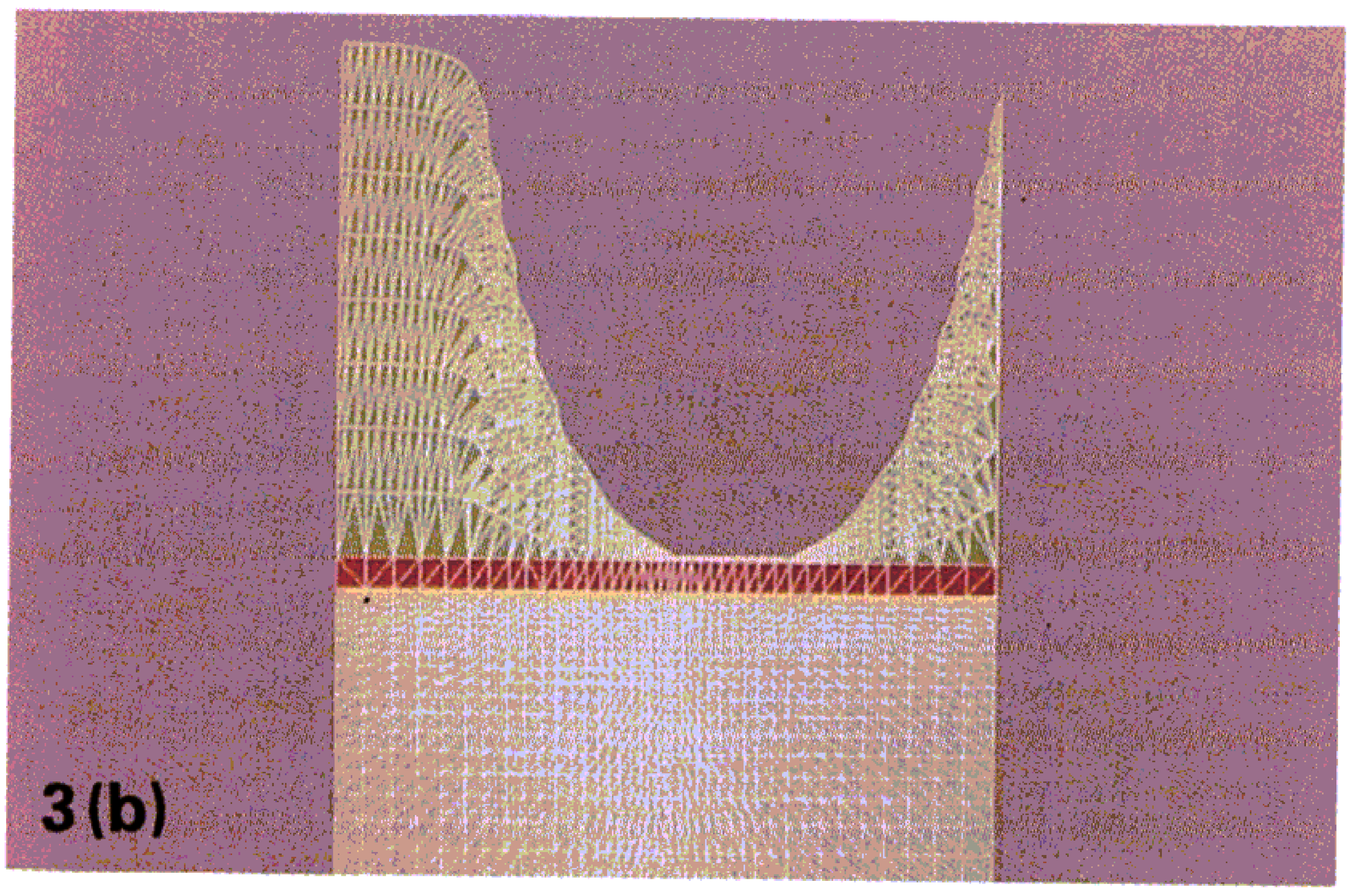
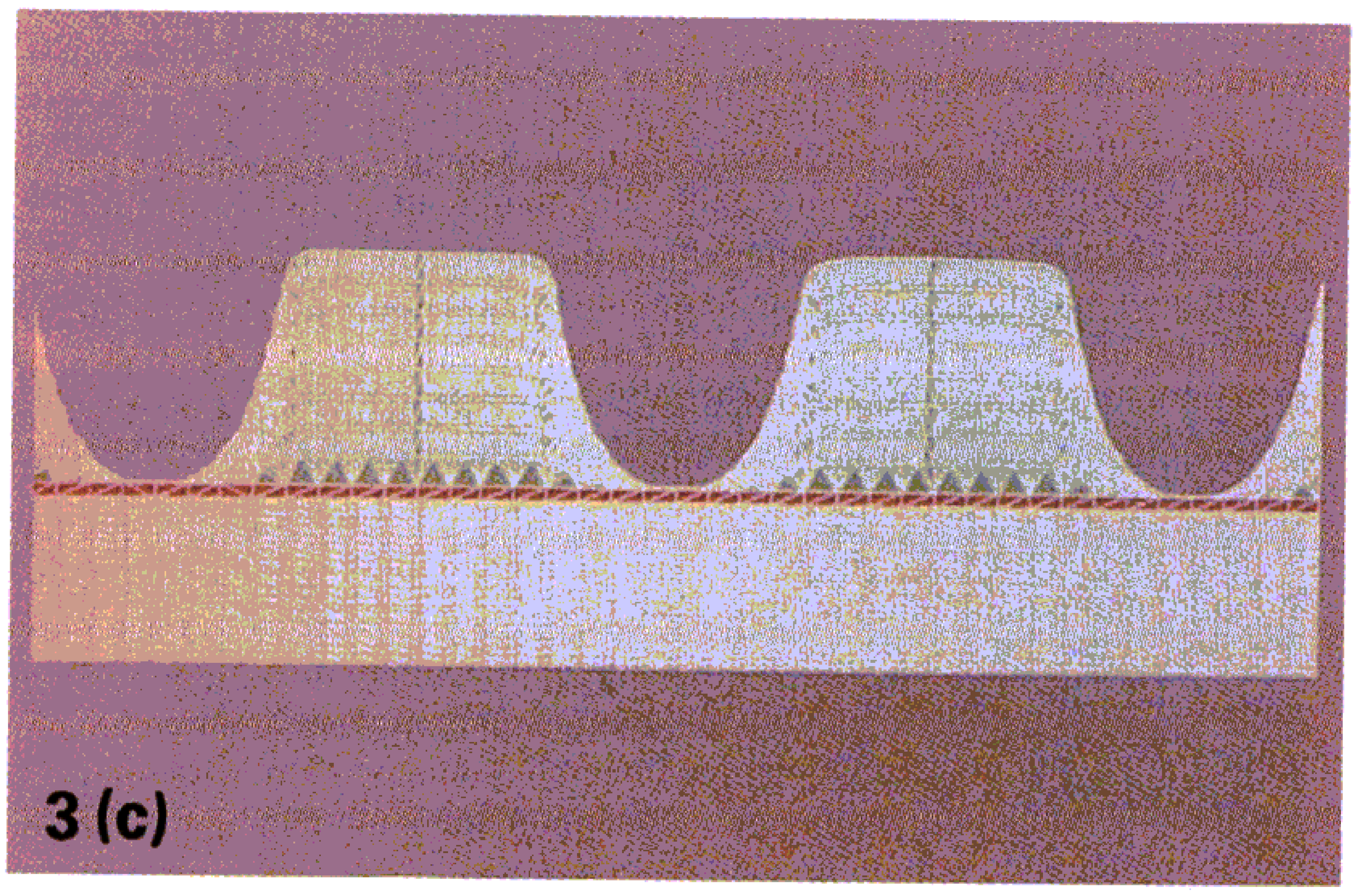


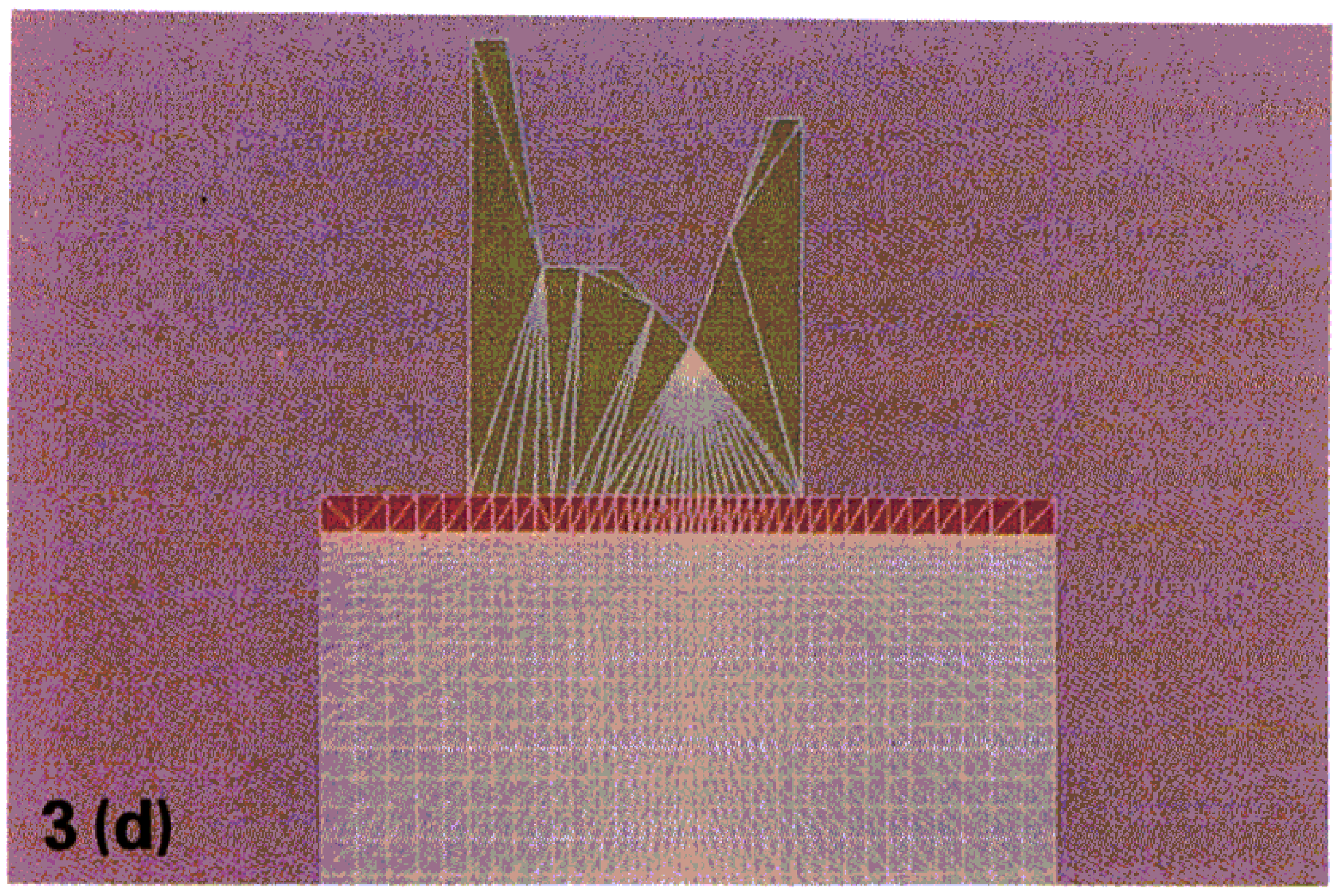
Fig. 1. (a) FEDSS mesh for a structure consisting of a trench formed in silicon, covered by a triple layer of insulators, and filled with polysilicon. The top surface is partially covered by pad nitride. (b) FEDSS mesh for the structure shown in Fig. 1(a) after thermal oxidation to form a semi-recessed oxide region. (c) SEM picture for actual semi-recessed oxide region simulated in Fig. 1(b). (d) Simulated hydrostatic pressure distributions in the semi-recessed oxide region at the end of oxidation. High compressive (green) hydrostatic pressure exists in the nitride pad region on top of the lateral bird's beak area, and high tensile (red) hydrostatic pressure exists around the vertical bird's beak region. The maximum compressive and tensile regions are approximately 10^9 dynes/cm^2. These quantities are shown here on a logarithm scale, with 64 separate contours. (e) Here, the 2-D mesh in Fig. 1(a) was extruded into the third dimension, with some of the pad nitride cut away. (f) The top part represents the cross section indicated by points C → D → E in Fig. 1(e) after growing oxide for 10 min. The bottom part shows a blowup of the area of interest. (g) The hydrostatic pressure distribution for the bottom part of Fig. 1(f). (See overleaf for Fig. 1(g).)

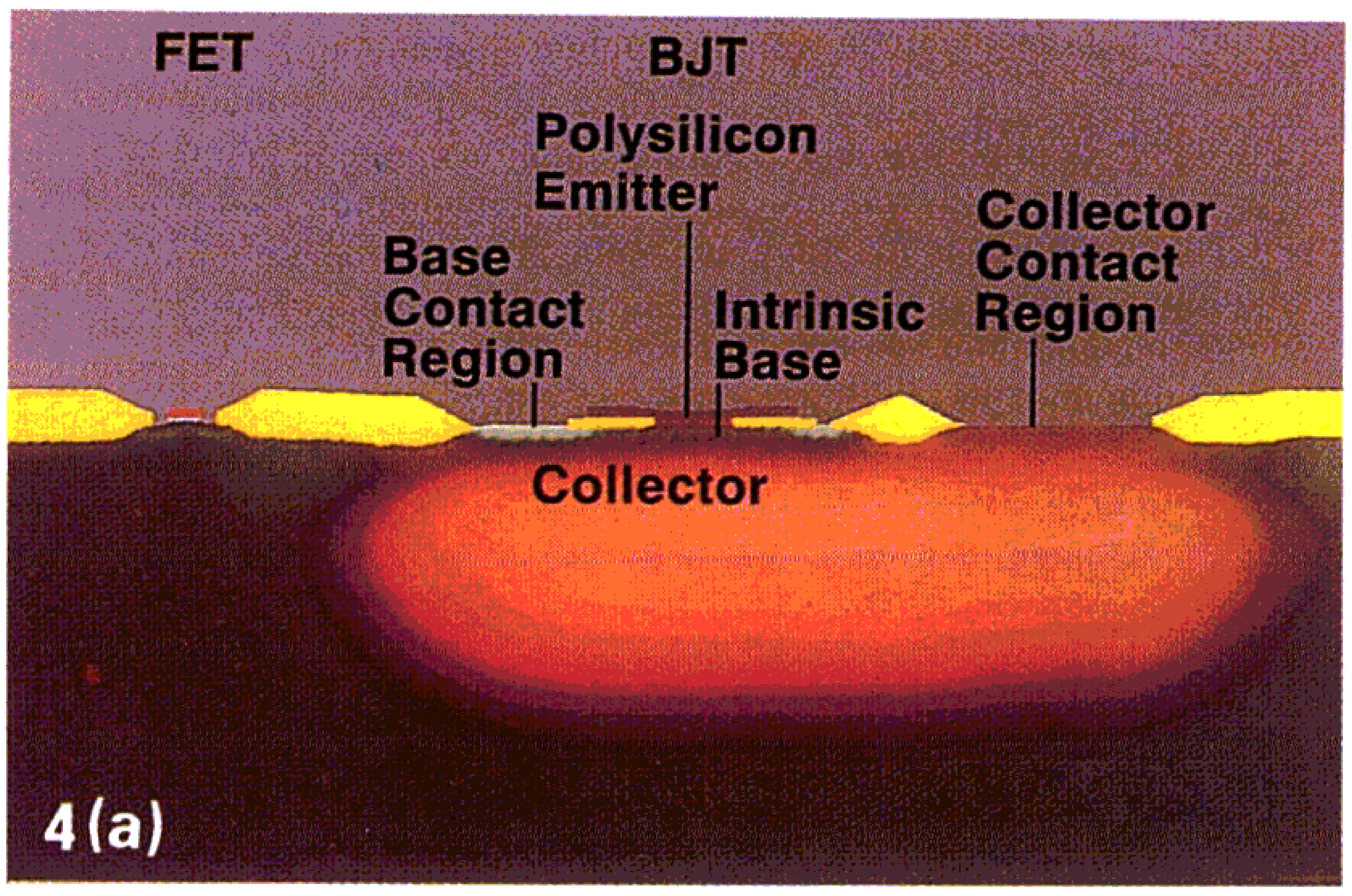












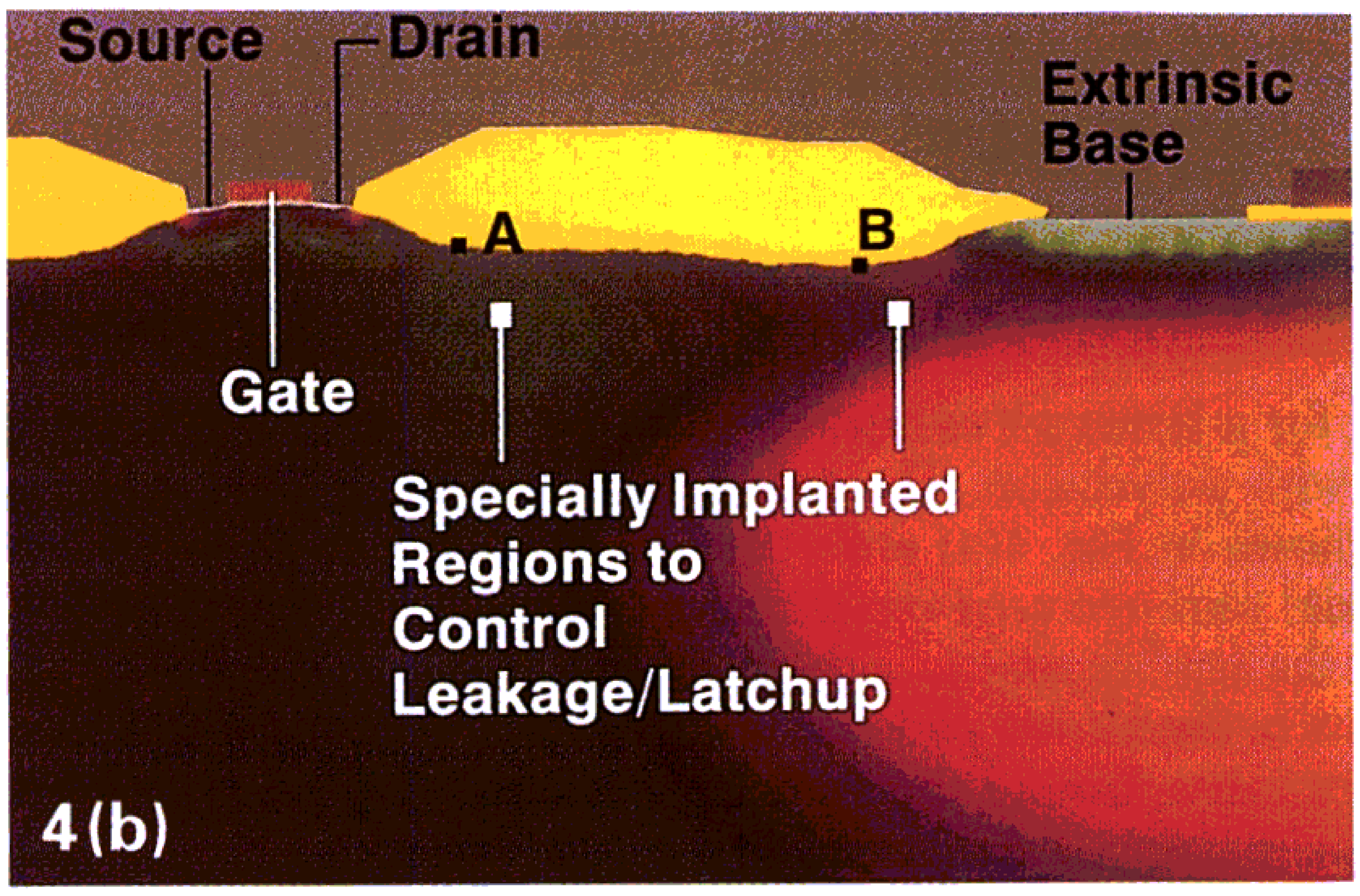
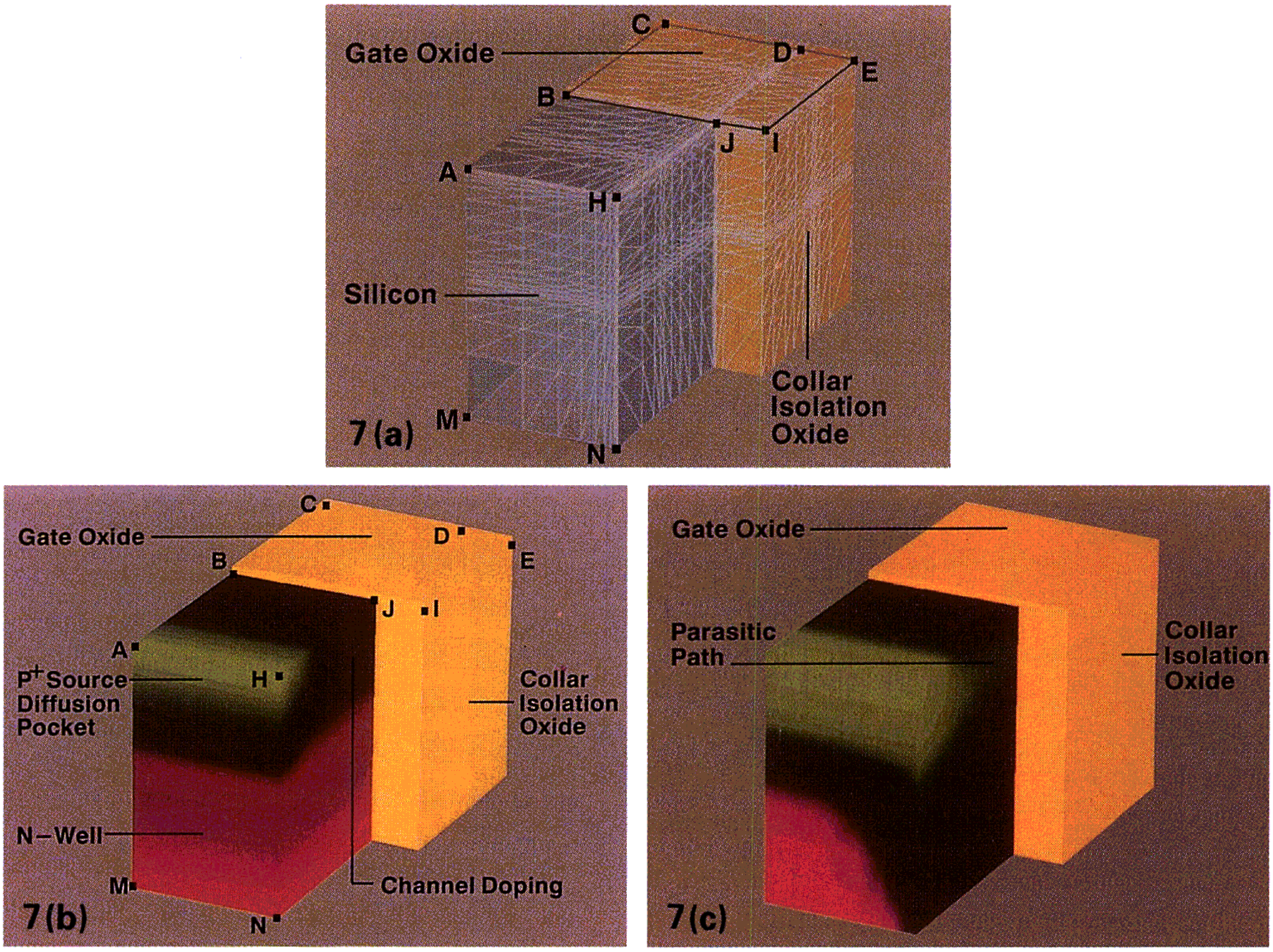
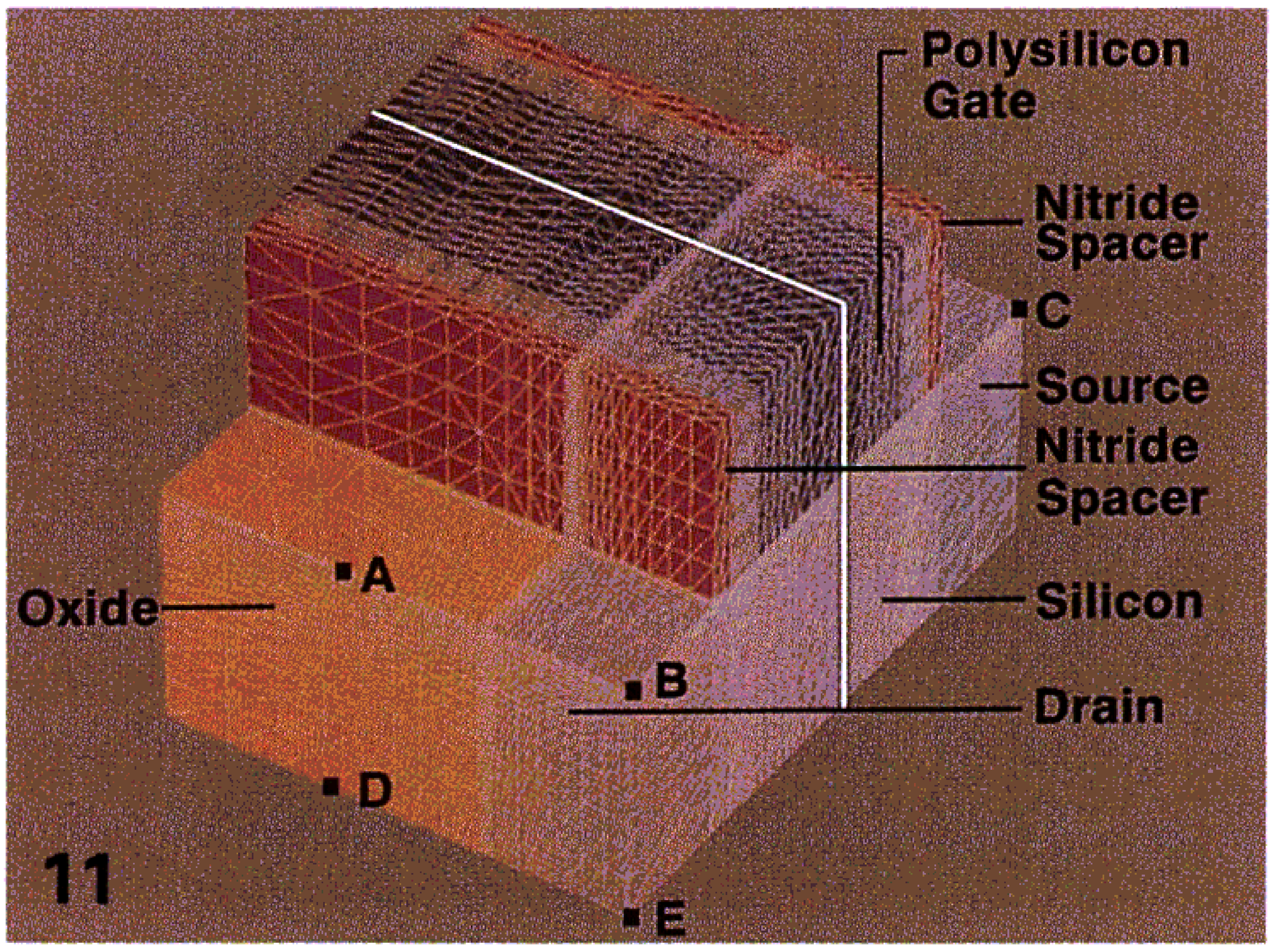


Fig. 3. Example of FEDSS-SAMPLE mapping options. (a) A mapped, reflected, and meshed structure. (b) Translation of an isolated resist structure. (c) Periodic resist structure generated from translation. (d) This unusual looking structure is shown here to indicate that the user can define his own structure, and can also specify the mesh density in the photoresist structure. The mesh in the photoresist is automatically matched up with the mesh in the semiconductor structure, thereby enabling subsequent process calculations for the two regions.

Fig. 4. BiCMOS cross section generated by FEDSS. (a) An *n*-MOSFET and a vertical *npn* BJT are shown. (b) Blowup of the MOSFET to show the source and drain, which contain LDD and LDS/halo structures.





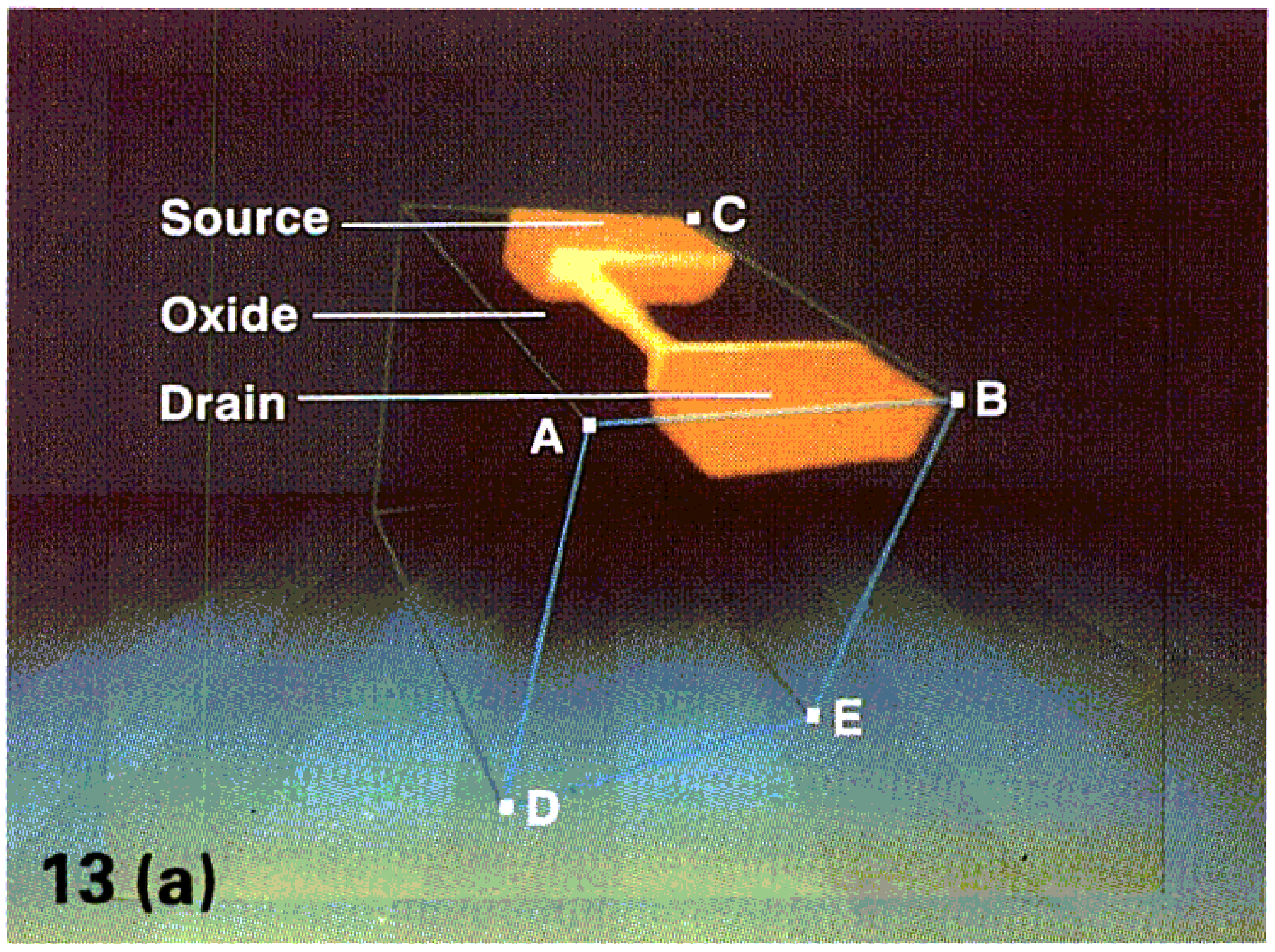
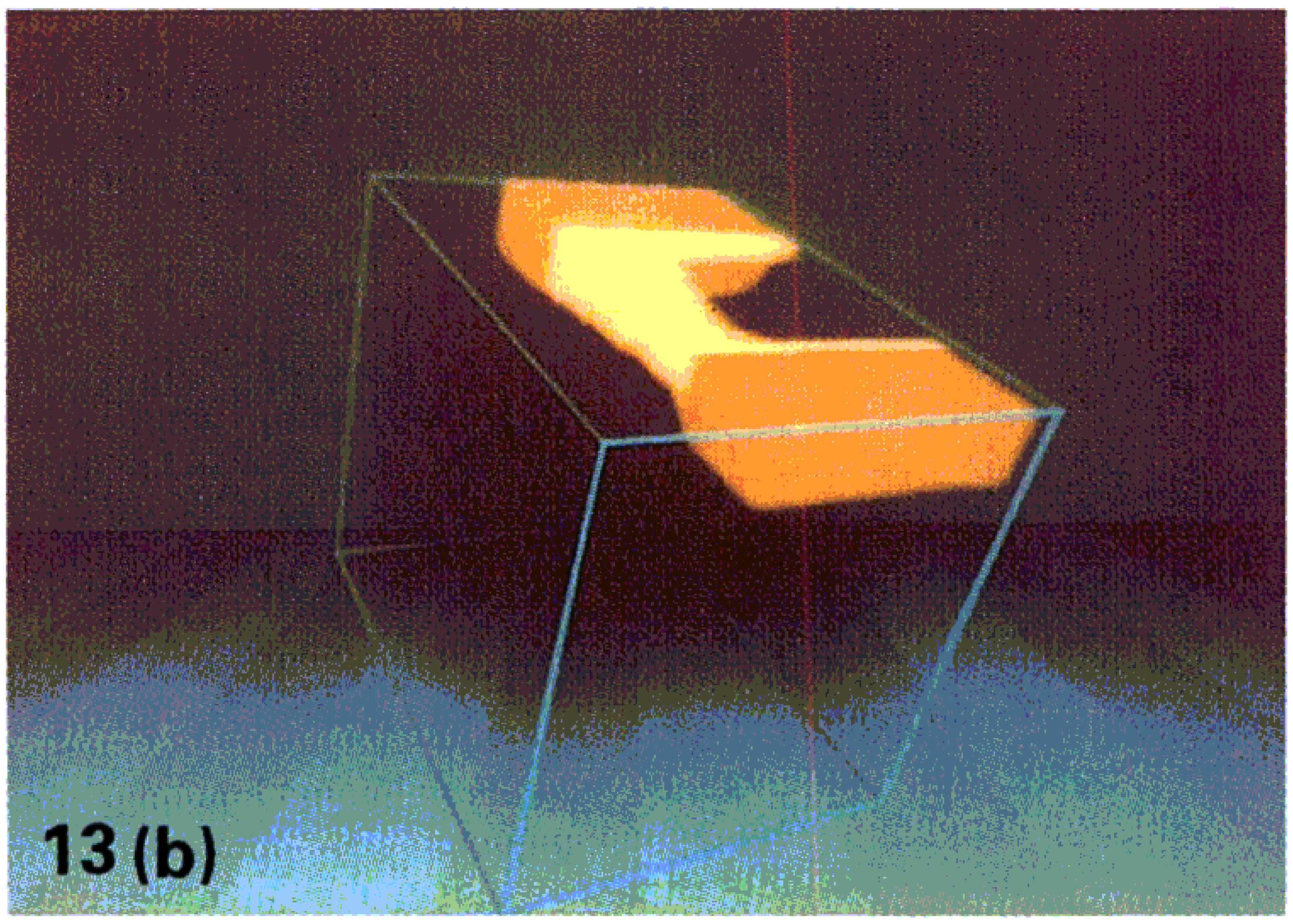
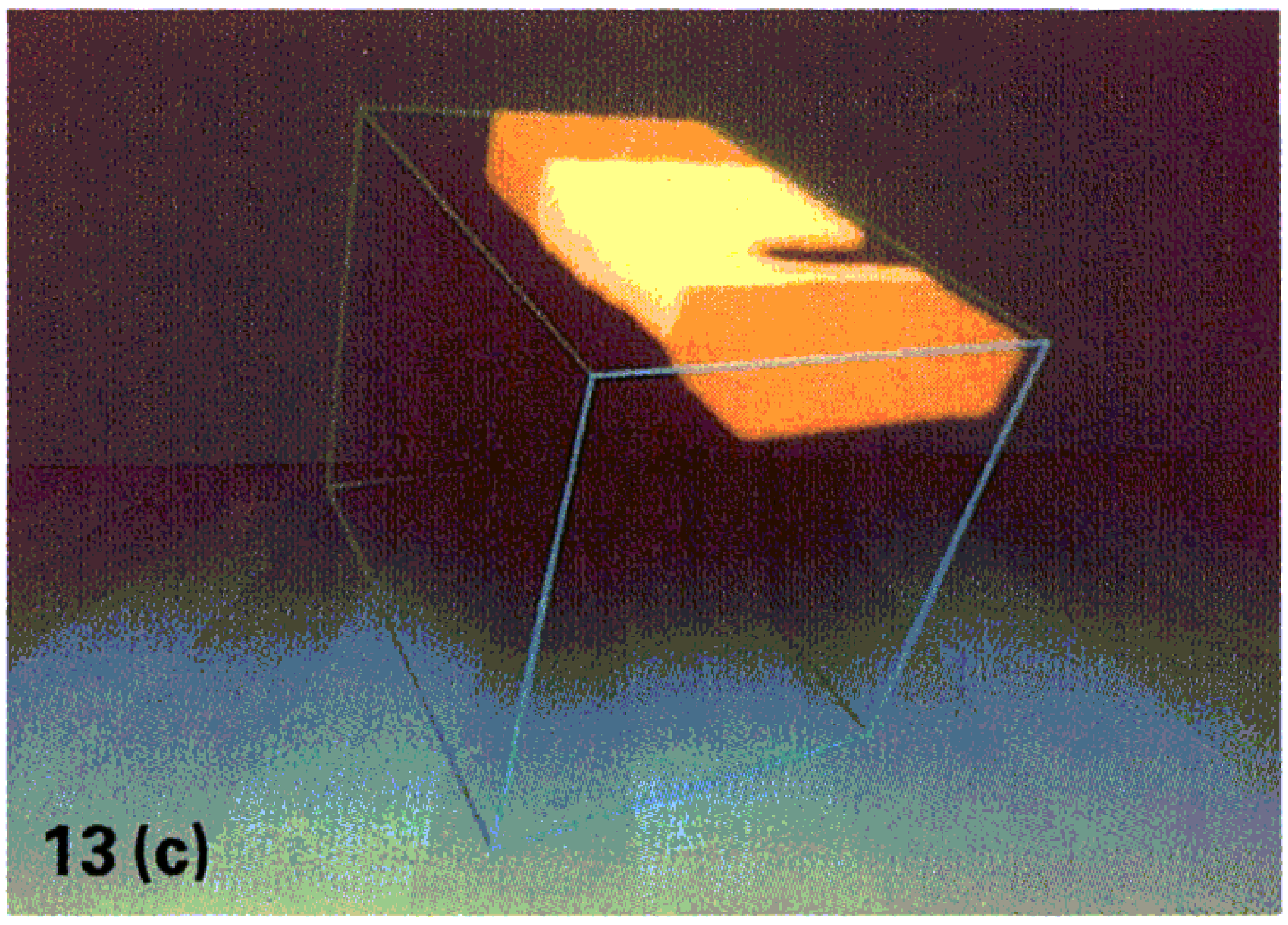


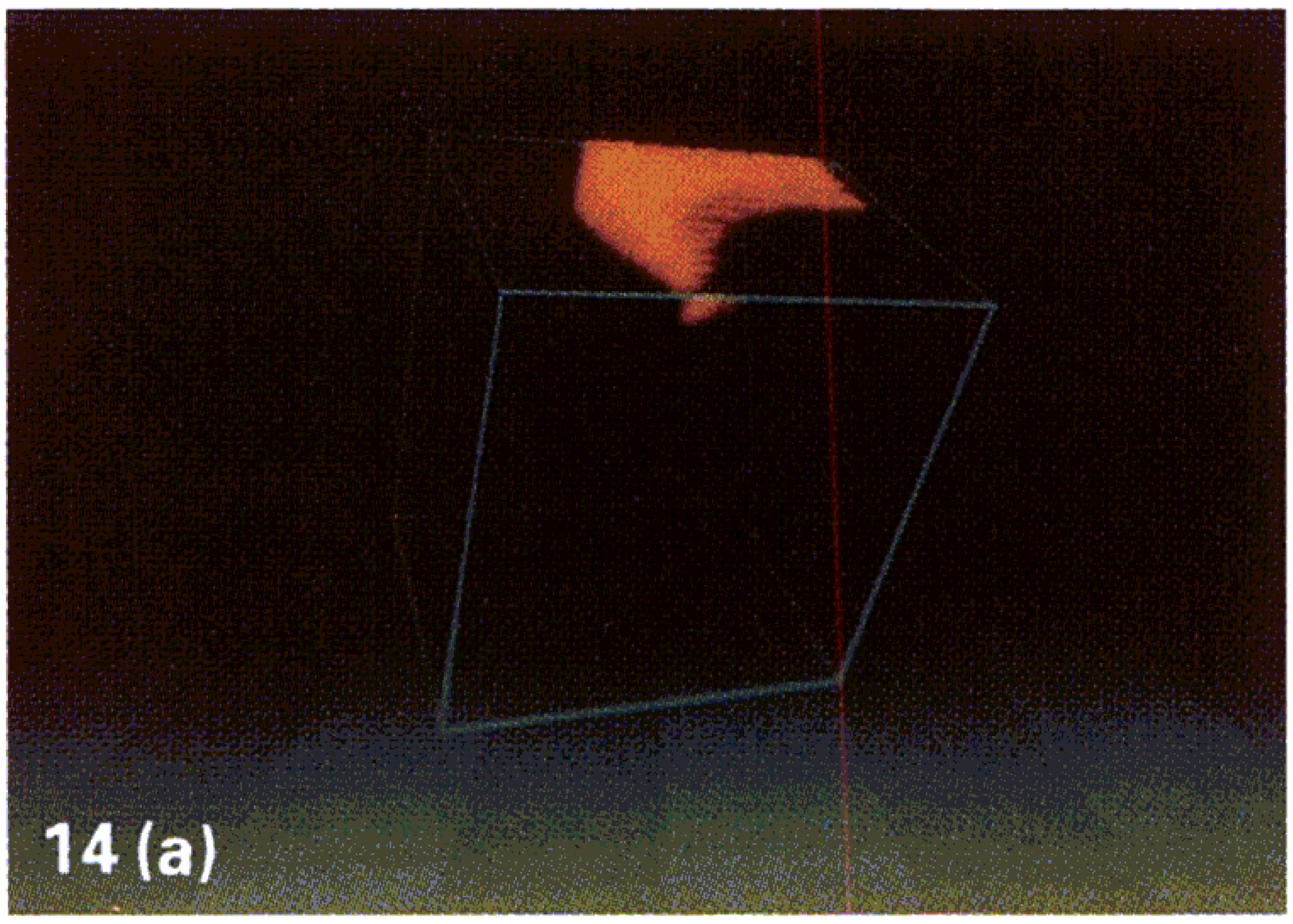
Fig. 7. (a) Finite-element mesh for model. Blue is silicon, yellow is oxide. Oxide has been removed from the portion closest to the observer for viewing underlying silicon. (b) Doping concentration. Green is *p*-type, red is *n*-type silicon. (c) Hole minus electron concentration showing formation of parasitic conduction path on trench sidewall.

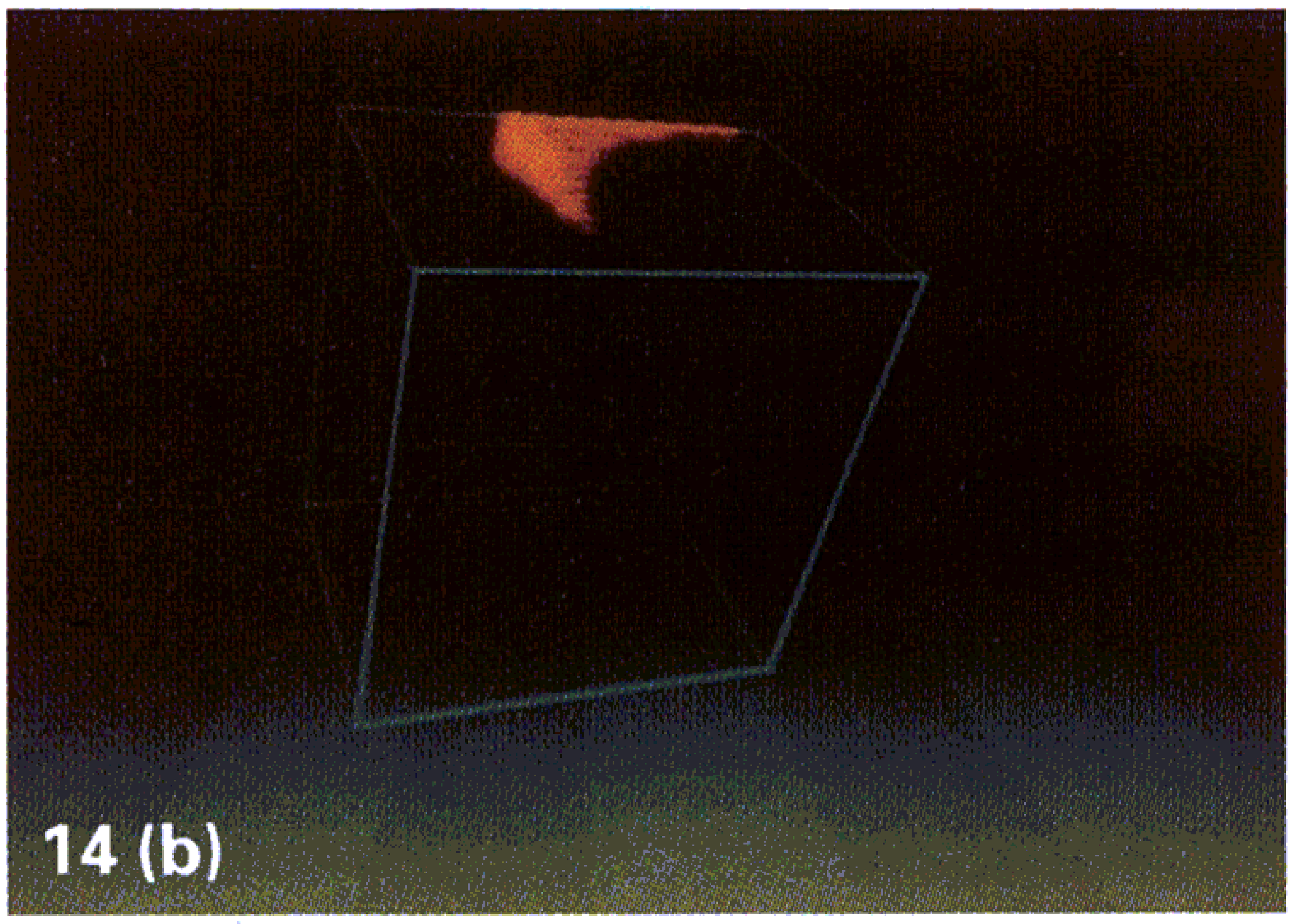
Fig. 11. A typical 3-D mesh used for device modeling: gray—silicon; yellow—oxide; blue—polysilicon; red—nitride. The points A, B, . . . , E correspond to the same points in Fig. 13(a). The cross section indicated by the bright white line represents the left-hand side of the device sketched in Fig. 10(c).

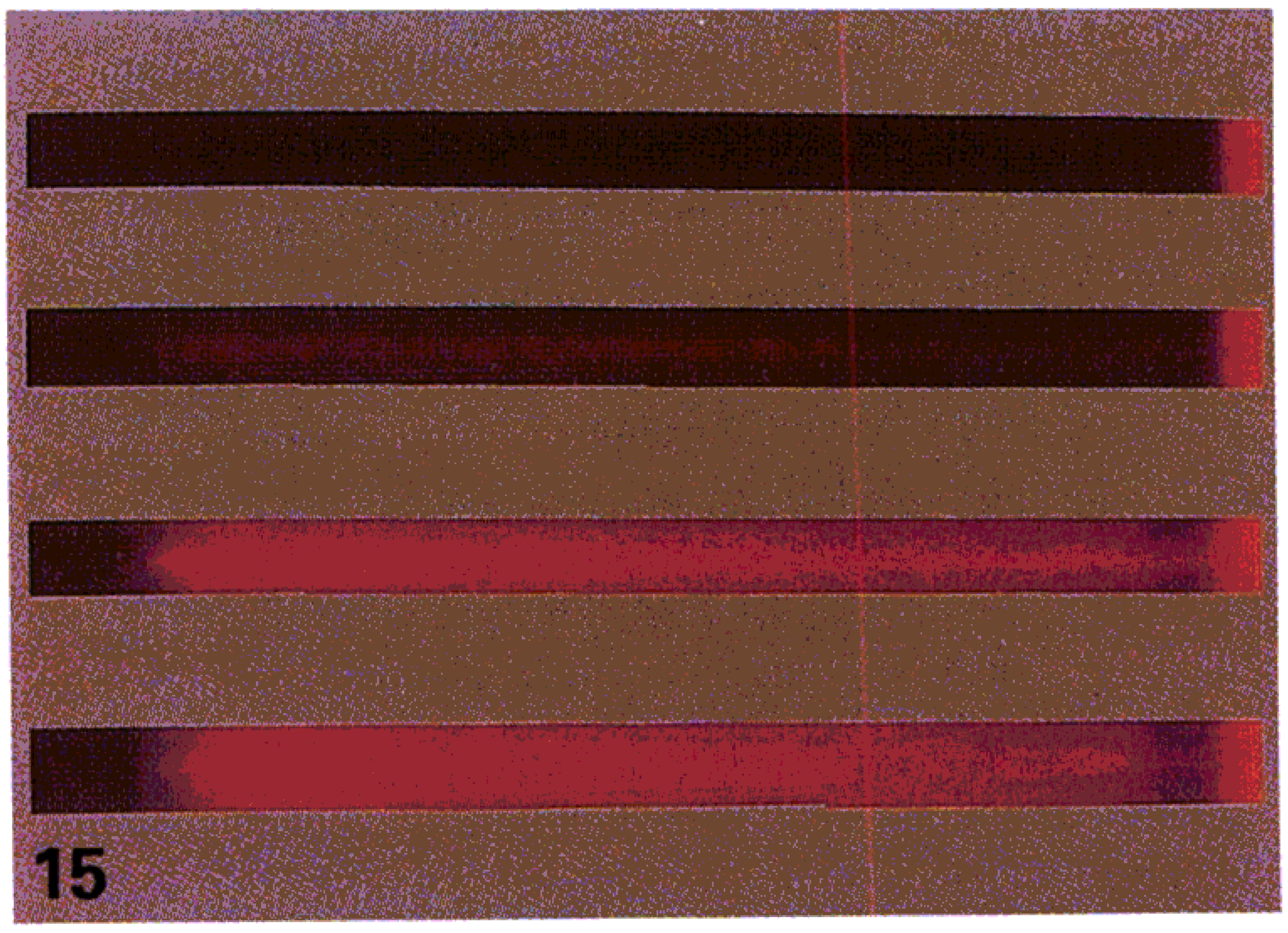
Fig. 13. Electron density in a trench-isolated MOSFET, showing turn-on as the gate bias is increased from (a) to (c). Note that the device corner inverts at a lower gate bias than does the planar region. (See overleaf for Figs 13(b) and (c).)











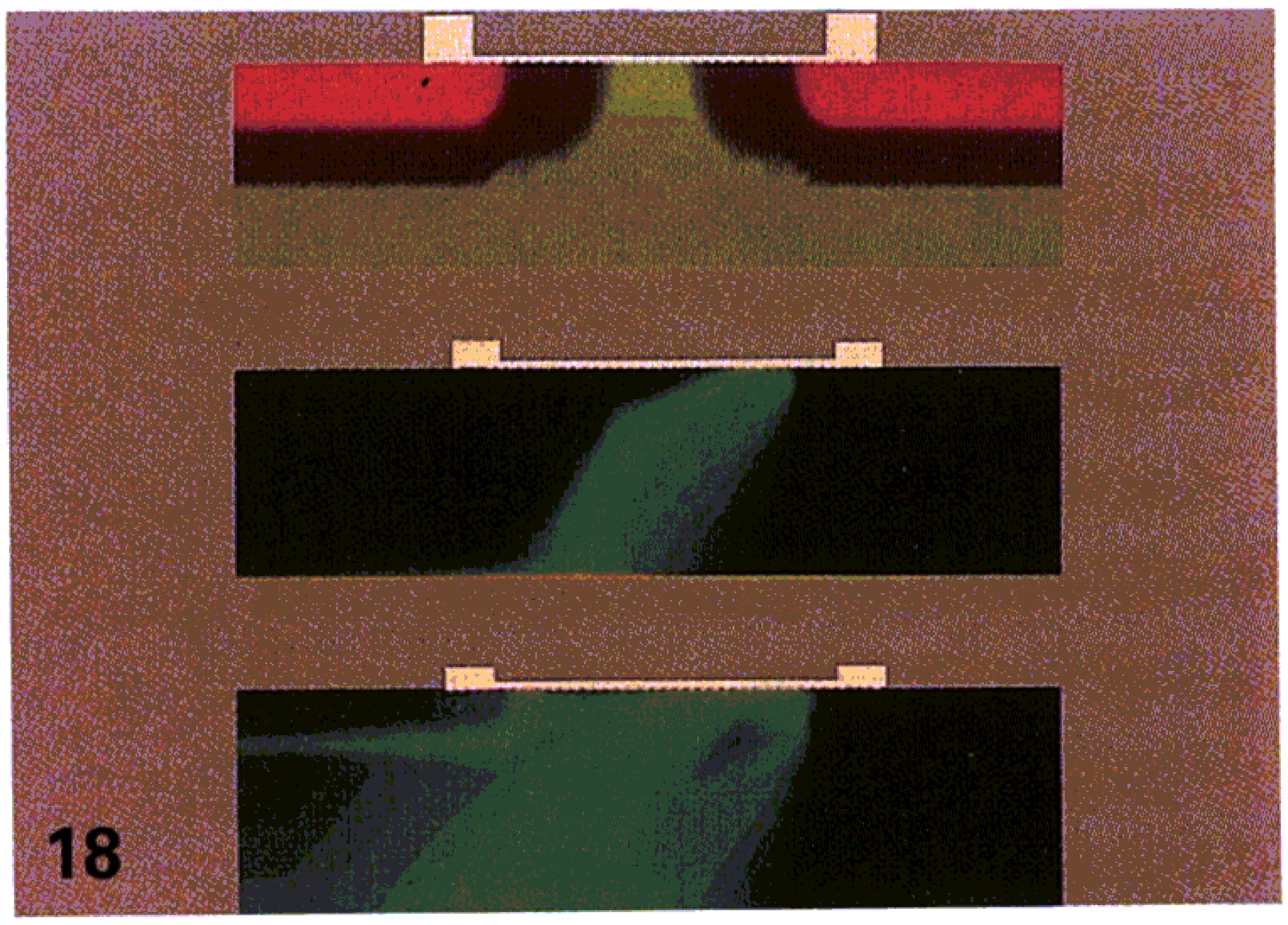


Fig. 14. Cross section of the electron density at mid-channel with the gate bias as the third axis. (a) $T = 300$ K. (b) $T = 77$ K.

Fig. 15. A sequence of contour plots of electron charge concentration that illustrate the evolution of the electron charge concentration after an α-particle strike. The right-hand side of each of the four plots represent the region where the *pn* junction lies. The α-particle enters from the right-hand side. The top cross section shows the initial situation before the α-particle hits. The next cross section down indicates the electron charge distribution 3 ps after the α-particle strike, while the next two cross sections show the situation at 90 and 180 ps, respectively.

Fig. 18. Simulation using FIELDAY to illustrate the effects of impact ionization and incomplete ionization for a 0.35-μm channel length *n*-MOSFET device with LDD structure. (Top) Doping concentration. Red is *n*-type, green is *p*-type silicon. (Middle) and (lower) Hole concentration at 77 K, for $V_{DS} = 2.0$ V, $V_{GS} = 4.0$ V, and $V_{SX} = 0.0$ V. (Middle) Simulation assuming complete ionization. (Lower) Simulation with incomplete ionization model.

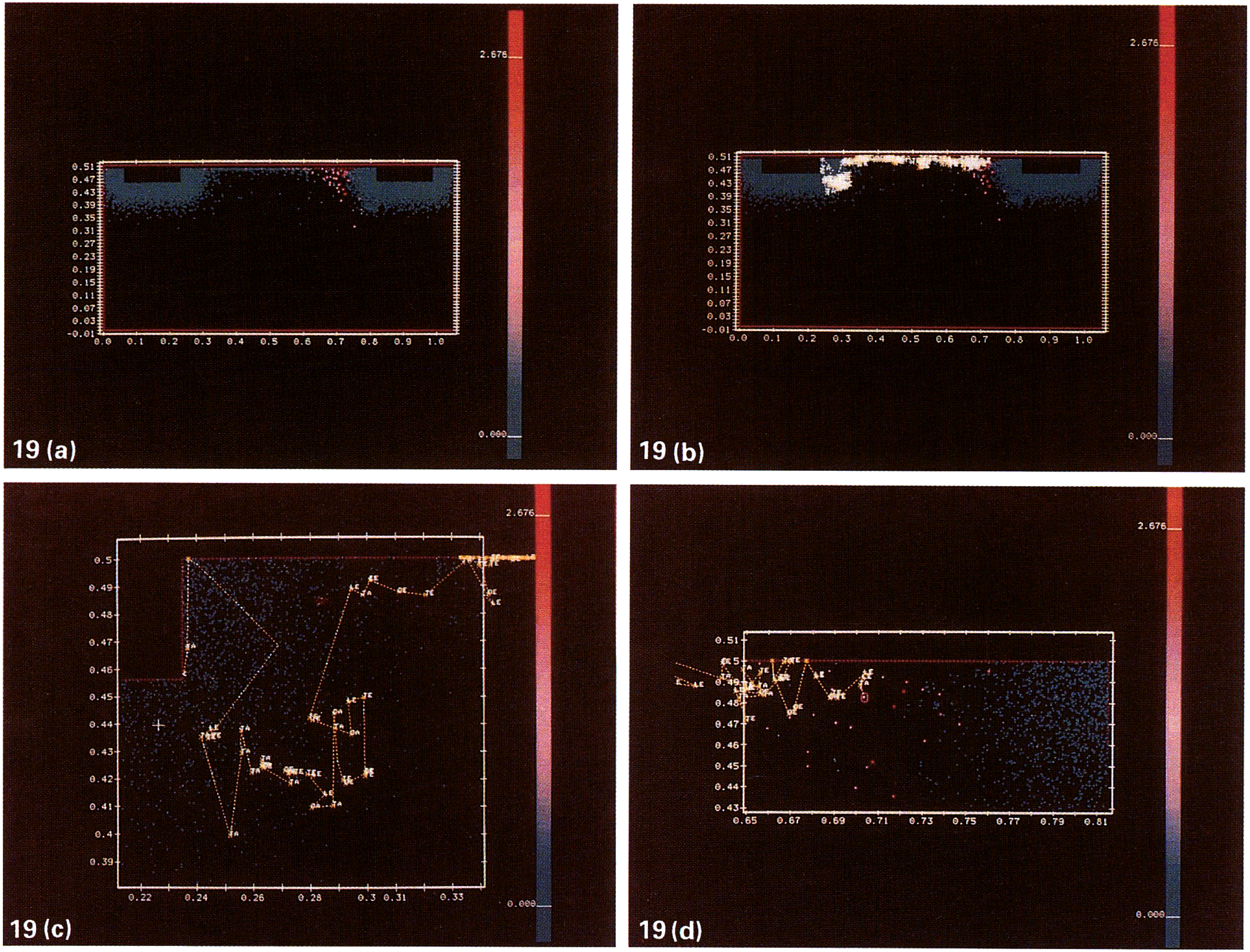


Fig. 19. A Monte Carlo simulation using DAMOCLES of a 0.35-μm channel length n-MOSFET. The oxide thickness is 12 nm. Gaussian profiles were assumed for the source and drain regions with a peak concentration of $2 \times 10^{20}\,\text{cm}^{-3}$ n type. The substrate doping was $3 \times 10^{16}\,\text{cm}^{-3}$ p type, and a surface channel tailor implant had a peak concentration of $1.83 \times 10^{17}\,\text{cm}^{-3}$ p type. The bias conditions assumed here are $V_{\text{drain–source}} = 5.0$ V, $V_{\text{gate–source}} = 2.5$ V, and $V_{\text{source–sub}} = 0.0$ V. Approximately 8000 electrons are tracked. (a) One snapshot in time. (b) The past trajectory for one of the electrons in (a). (c) Blowup of (b) near the source end. Note that scattering events are labeled. (d) Blowup of (b) near the drain end.

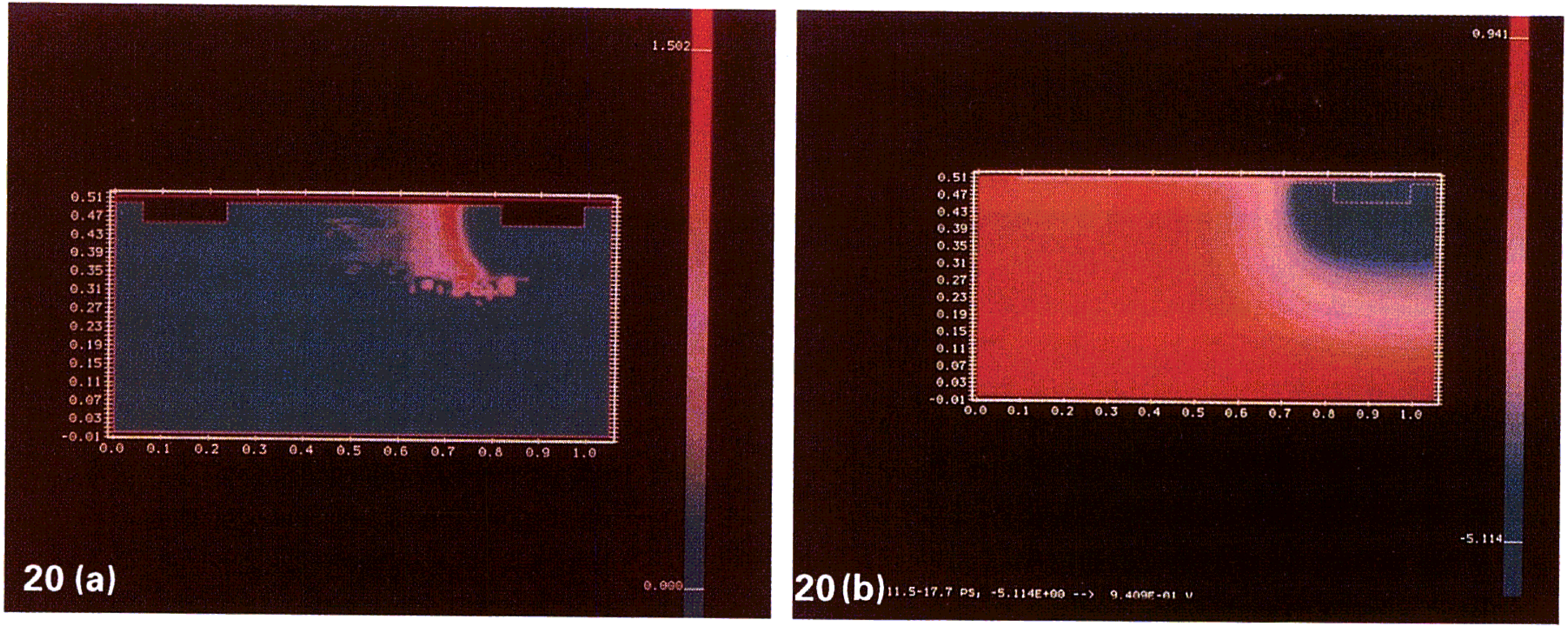
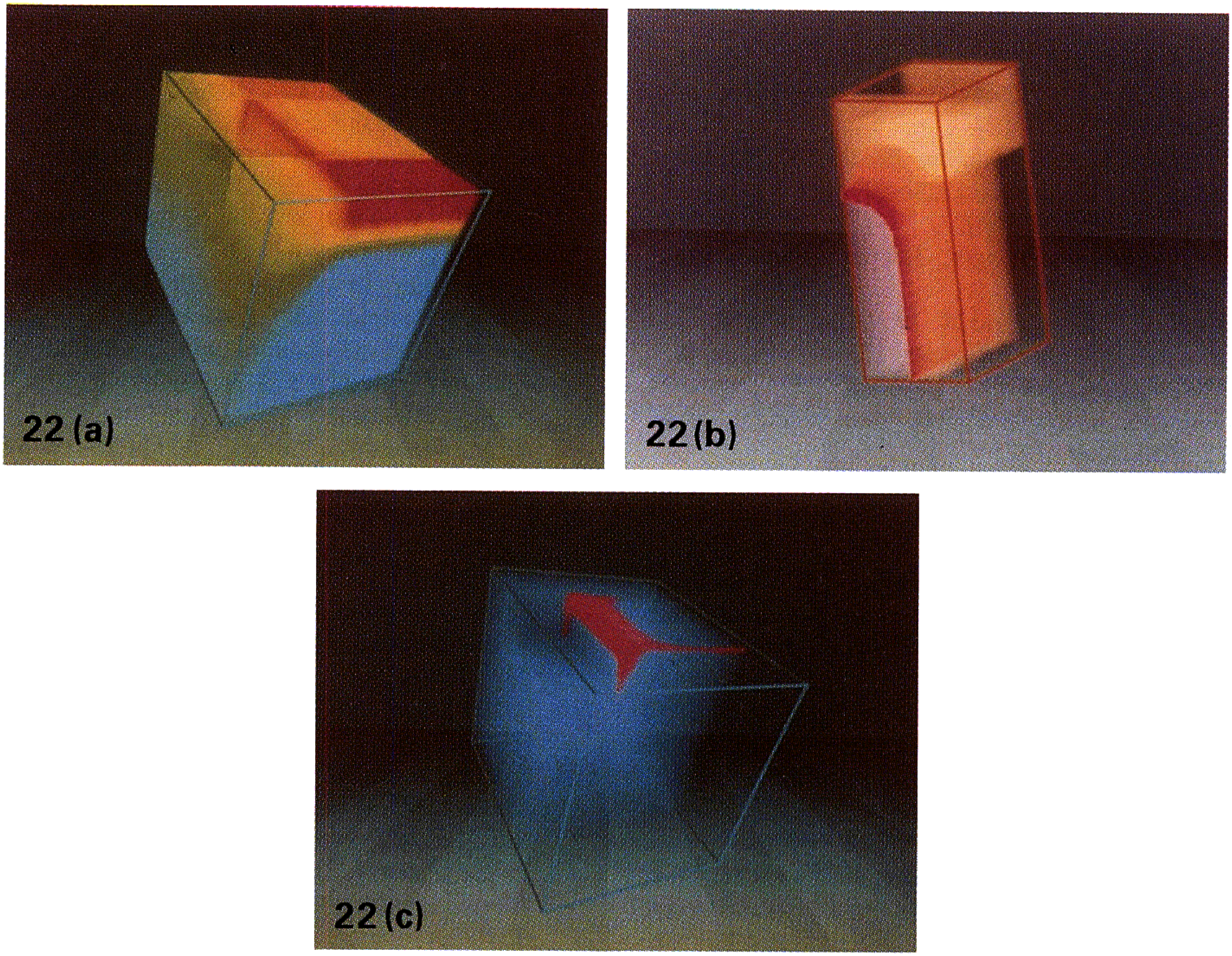


Fig. 20. Contour plots of calculated (a) average electron energy, and (b) the negative of the electrostatic potential. The average energy in (a) ranges from 0 eV (blue) to 1.5 eV (red), while the electrostatic potential in (b) ranges from +5.1 V (blue) to −0.94 V (red).



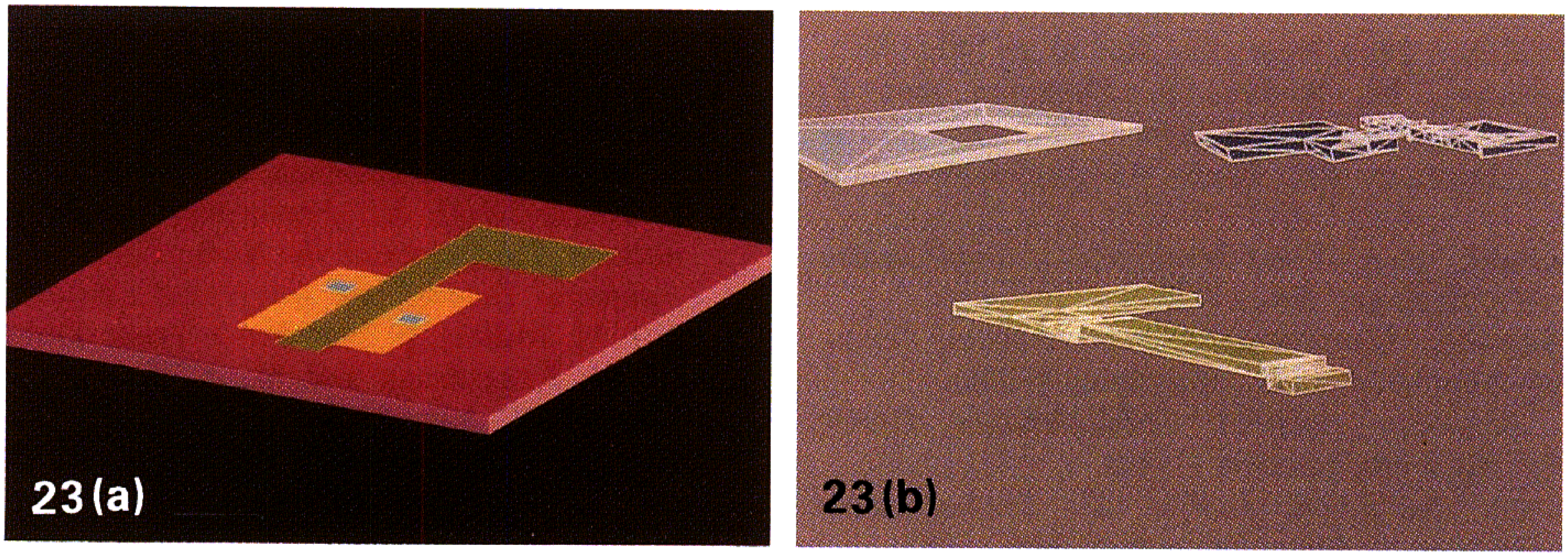


Fig. 22. Scientific visualization examples. (a) Electrostatic potentials in the trench-isolated MOSFET of Section 4.D. Low potential is shown as blue and high potential as red. (b) Electrostatic potentials in the modeled region in Section 4.C. The opaque red shell is a selected range of intermediate potentials. (c) Electron concentration for the modeled region of Section 4.D. The opaque red region shows the location of high electron concentrations in the channel.

Fig. 23. OYSTER representation of a MOSFET. (a) The green is a polysilicon line. The yellow represents the gate oxide. The two blue regions are metal contacts to the source and drain regions. (b) Pieces extracted from the FET structure and meshed.