C_{60} as a versatile electron contact material for crystalline silicon solar cells

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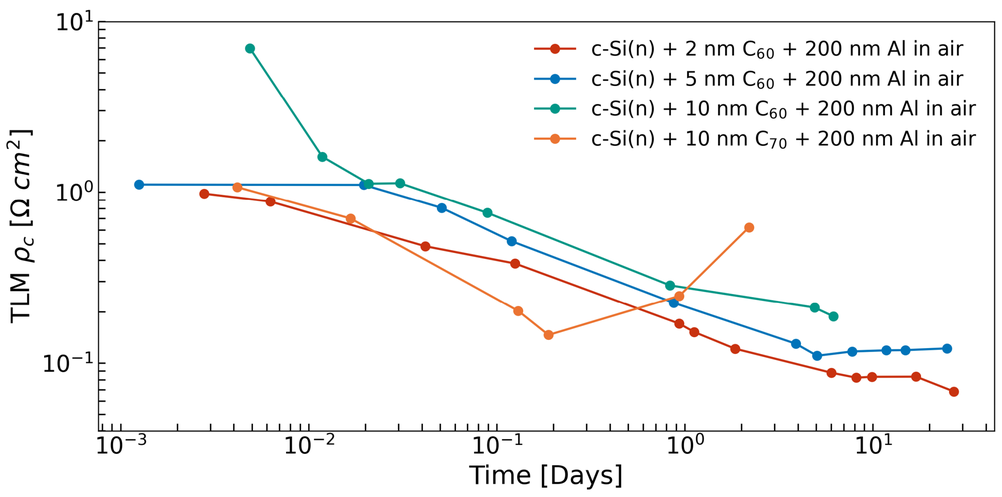
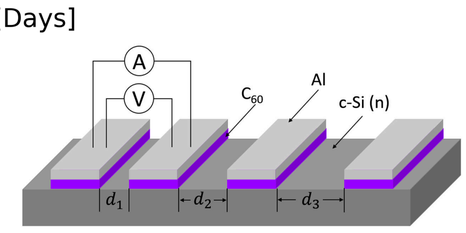
Abstract

C_{60} has been used as an electron contact in organic/perovskite solar cells and LEDs. However, it has not been thoroughly tested with crystalline silicon solar cells. In this study, we conducted tests on C_{60}'s ability to perform two functions in c-Si solar cells. The first function is direct electron contacts to c-Si. The second is as a buffer or protection layer for ultrathin (~10 nm) polysilicon contacts.

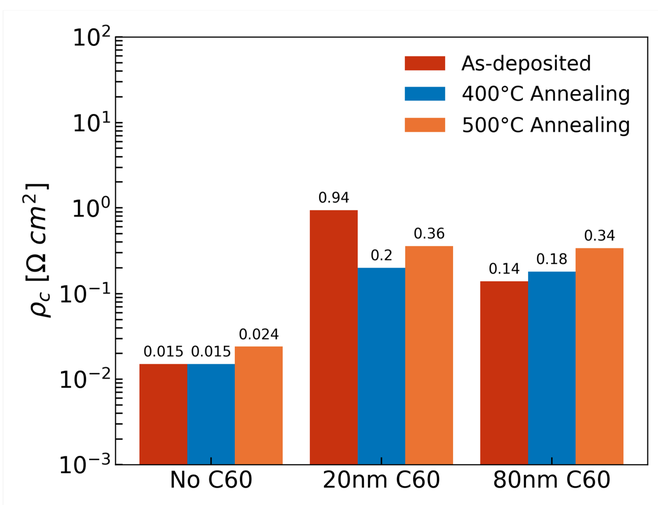
Application #1: Direct contact to c-Si

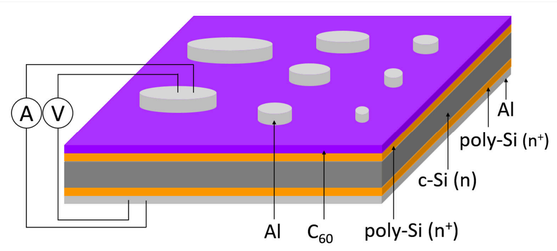




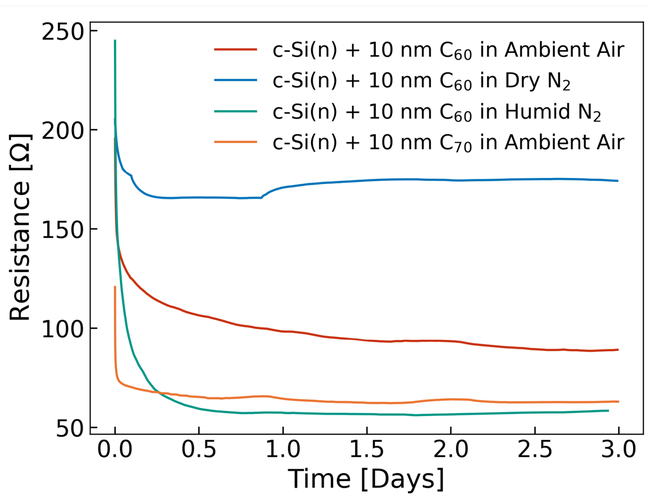
- Contact resistivity ρ_c of C_{60}/c-Si and C_{70}/c-Si electron contacts as a function of time with different C_{60} thickness (2, 5 and 10 nm) when stored in air.
- In all cases, ρ_c decreases with air exposure time.

Application #2: Barrier layer for ultrathin (~10 nm) polysilicon contacts

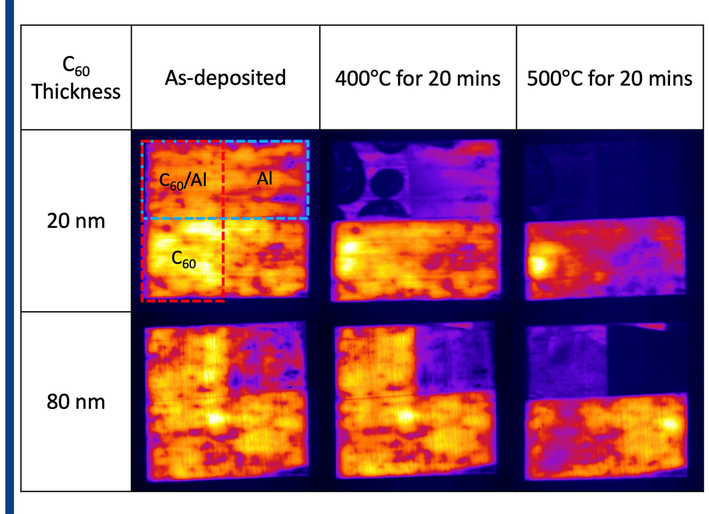




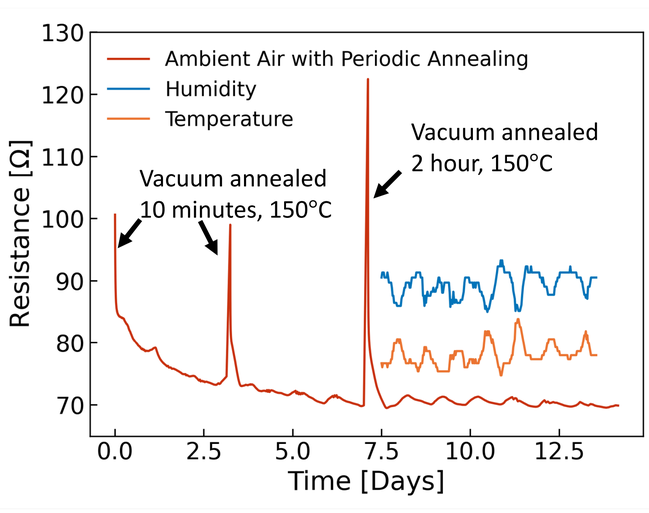
- ρ_c of SiO_2 /n^+poly-Si/C_{60}/Al electron contacts as a function of annealing temperature with different C_{60} thickness (20, 80 nm).
- ρ_c for SiO_2/n^+poly-Si/Al without the C_{60} layer are included for reference.
- ρ_c does not improve with air exposure time.
- Even for 80 nm, ρ_c is low enough for full-area contacts.



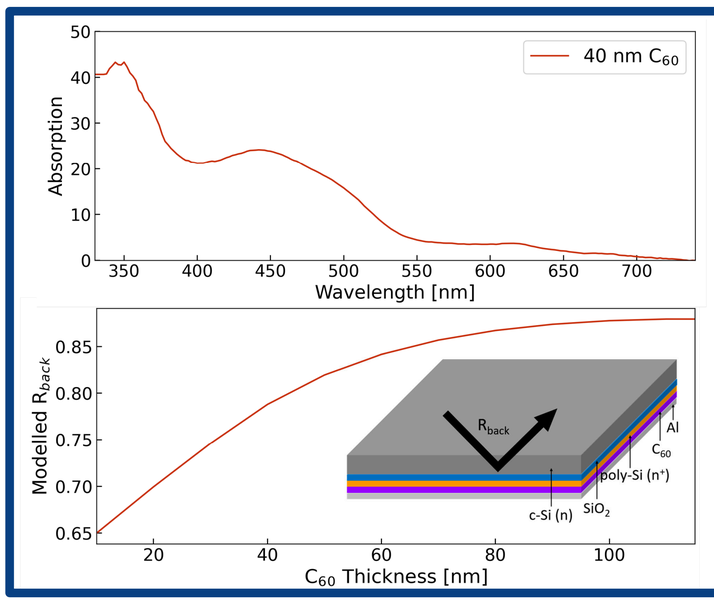
- Resistance of C_{60}/c-Si or C_{70}/c-Si electron contacts across a fixed gap width, as a function of time in environments with different level of humidity.
- Humidity seems to play a role in the decreasing of resistance.
- C_{70} decreases faster than C_{60}.



- Photoluminescence images of samples with C_{60} (20, 80 nm) and Al (~200 nm) thin films on top of poly-Si passivated electron contacts. Samples are stored in air.
- 80 nm of C_{60} can protect the sample up to 400°C.



- Resistance of C_{60}/c-Si contacts across gap, as a function of time, in ambient air with periodic annealing in vacuum oven.
- The reaction of C_{60} and C_{70} with humidity is reversible.
- The resistance varies with humidity and temperature on a daily cycle.



- The absorption of C_{60} is too high to be used on the front of a solar cell.
- For a rear side application, the simulated weighted back reflection R_{back} shows moderate rear reflection of around 88% with ~100 nm of C_{60}.

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