Bandlimited optical intensity channels, arising in applications such as visible light communications, require that all signals satisfy a bandwidth constraint as well as average, peak, and non-negativity amplitude constraints. In this paper, a 2-D signal space for bandlimited optical intensity channels is presented. A novel feature of this model is that the non-negativity and peak constraints are relaxed, and the signal space parameterizes the probability of the negative or peak amplitude excursions in the output. Although the intensity channel only supports non-negative amplitudes, the impact of clipping on system performance is shown to be negligible if the likelihood of the negative excursion is small. A tractable approximation using finite series is used to accurately compute the probability of clipping under average and peak optical power constraints. The optical power and spectral efficiencies using hexagonal lattice constellations are computed. Schemes designed in this paper have higher average and peak optical power gains than $M$-ary pulse amplitude modulation (PAM) using previously established techniques for spectral efficiencies greater than 2.5 and 3.5 bits/s/Hz, respectively. For high spectral efficiency, e.g., greater than 6 bits/s/Hz, the proposed scheme attains a more than 2-dB average and peak optical power gain over 16-PAM using the previous approaches.